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तरल पावर प्रणाली तथा घटक – शब्दावली

(पहला पुनरीक्षण)

Indian Standard

FLUID POWER SYSTEMS AND COMPONENTS — VOCABULARY

(First Revision)

UDC 621·8·032 : 001·4

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

April 1992

Price Group 14

Indian Standard

FLUID POWER SYSTEMS AND COMPONENTS — VOCABULARY

(First Revision)

NATIONAL FOREWORD

This Indian Standard (First Revision) which is identical with ISO 5598 : 1985 'Fluid power systems and components — Vocabulary', issued by the International Organization for Standardization (ISO) was adopted by the Bureau of Indian Standards on the recommendation of the Basic Fluid Power Sectional Committee (PE 14) and approval of the Production Engineering Division Council.

This standard was first published in 1982. To align it with international practices, ISO 5598 : 1985 has been adopted in this revision.

The text of the ISO standard has been approved as suitable for publication as Indian Standard without deviation. Certain conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words 'International Standard' appear, referring to this standard, they should be read as 'Indian Standard'.
b) Comma (,) has been used as a decimal marker while in Indian Standards, the current practice is to use point (.) as a decimal marker.
c) The word 'IEC or ISO Standard' appearing in clause 4.6.0 should be read as 'Indian Standard'.

In this adopted standard, reference appears to certain International Standards for which Indian Standards also exist. The corresponding Indian Standards which are to be substituted in their place are listed alongwith their degree of equivalence for the editions indicated:

International Standard	*Corresponding Indian Standards*	*Degree of Equivalence*
ISO 1219 : 1976 Fluid power systems and components— Graphic symbols	IS 7513 : 1973 Graphical symbols for fluid power systems	Technically equivalent
IEC Publication No. 50 (37) Automatic controlling and regulating systems [superseded by IEC publication No. 50 (351)-1975 International electrotechnical vocabulary, chapter 351 : Automatic control]	IS 1885 (Part 49) : 1978 Industrial process measurement and control	Technically equivalent
ISO 2382/1 : 1984 Data processing— vocabulary — Part 1 : Fundamental terms	IS 1885 (Part 52/Sec 1) : 1965 Electrotechnical vocabulary : Part 52 Data processing, Section 1 Fundamental terms	Technically equivalent

The technical committee responsible for the preparation of this standard has reviewed the provisions of following ISO standards and has decided that they are acceptable for use in conjunction with this standard:

ISO 554 : 1976	Standard atmospheres for conditioning and/or testing — Specifications
ISO 558 : 1980	Conditioning and testing — Standard atmospheres — Definitions
ISO 3534 : 1974	Statistics — Vocabulary and symbols

Typographical Error

While adopting the text of this International Standard, the following typographical errors were noticed:

Reference	*Corrections to be Effected*
Cl. 5.8.6	Read 'de-aerator' *for* 'de-aerater'
Cl. 5.9.3.5.7	Read 'isocyanate' *for* 'socyanate'
Alphabetical index :	
—	Read 'Collapse pressure' *for* 'collapsed pressure'
—	Read 'Damping pressure……………………3.5.3.1.3 Dashpot……………………………………3.8' *for* 'Damping pressure……………………3.5.3.1.3 Dashpot……………………………………3.8 Damping pressure……………………3.5.3.1.3 Dash pot……………………………………3.8'
—	Delete the word 'Linear'
—	'Spring offset' — Read index '4.1.3' *for* '6.3.2'.

Only the English language text in the International Standard has been retained while adopting it in Indian Standard.

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0 Introduction

The purpose of this vocabulary is to provide in two languages (French and English) a comprehensive list of terms and definitions embracing devices and expressions used in the fluid power industry.

The "Vocabulary" is completed by two indexes, arranged alphabetically in English and in French, respectively.

The index relates each term to its number in the vocabulary and should be of help for reference purposes. Thus the reader is encouraged to refer back to the main vocabulary and its definitions, making sure he fully grasps the meaning of the term which may run counter to any superficial similarity.

Terms printed in italics are defined elsewhere in this International Standard.

1 Scope and field of application

This International Standard establishes the vocabulary for all fluid power systems and components excluding aerospace applications.

2 Fundamentals

2.0 General

2.0.0 **fluid power** : Means whereby energy is transmitted, controlled and distributed using a pressurized fluid as the medium.

2.0.1 **hydraulics** : Science and technology which deals with the laws governing liquid flow and pressure.

2.0.2 **hydrodynamics** : Science and technology which deals with the laws governing movement of liquids and forces which oppose this movement.

2.0.3 **hydropneumatic** : Functioning by means of a liquid and compressed gas.

2.0.4 **hydrostatics** : Science and technology which deals with the laws governing the equilibrium condition of liquids and the resulting pressure distribution.

2.0.5 **pneumatics** : Science and technology which deals with the laws governing compressed air flow.

2.1 Conditions of utilization

2.1.1 **operating conditions** : Operating conditions are indicated by the numerical values of the various factors relating to any given specific application of a unit. These factors may vary during the course of operations.

2.1.2 **rated conditions; standard conditions** : *Steady-state conditions* for which a component or system is recommended as a result of specified testing. The "rated characteristics" are, in general, shown in catalogues and are indicated : q_n, p_n, etc.

2.1.3 **continuous working conditions** : Conditions indicated by the values of the various factors which permit the unit to operate continuously. Continuous working conditions are indicated : q_c, p_c, etc. Often equals *rated (standard) conditions.*

2.1.4 **limiting conditions** : Conditions indicated by the minimum or maximum values of various factors which permit the unit to operate in extreme cases. The other effective factors and the duration of load being precisely defined. Limiting conditions are indicated : q_{min}, q_{max}, etc.

2.1.5 **steady-state conditions** : Conditions in which relevant variable parameters do not change appreciably after a period of stabilization.

2.1.6 **instantaneous conditions** : Conditions which exist at a specified point in time.

2.1.7 **actual conditions** : Conditions observed during operation.

2.1.8 **specified conditions** : Conditions required to be met in service.

2.1.9 **cyclic stabilized conditions** : Conditions in which the relevant parameters vary in a repetitive manner, similar conditions repeating at regular intervals.

2.1.10 **discontinuous conditions** : Conditions in which the relevant parameters do not attain stabilization as defined in 2.1.5 or 2.1.9.

2.1.11 **intermittent conditions** : Conditions in which periods of use are separated by periods of rest (either stopped or idling).

2.1.12 **acceptable conditions** : Conditions which permit a tolerable standard of performance and life.

2.2 Performance characteristics

2.2.1 efficiency : Ratio of an output to the corresponding input.

2.2.2 direction of rotation : Direction of rotation is always quoted as viewed looking at the shaft end. In dubious cases, a sketch should be provided.

2.2.2.1 clockwise [right hand] : *Direction of rotation* of the hands of a clock.

2.2.2.2 anticlockwise [left hand] : Rotation in the opposite direction to the hands of a clock.

2.2.3 Temperature

2.2.3.1 equipment temperature : Temperature of the unit at a specified position and measured at a specified point.

2.2.3.2 fluid temperature : Temperature of the fluid measured at a specified point.

2.2.3.3 temperature range of the equipment : Permissible temperature range within which the apparatus can operate satisfactorily.

2.2.3.4 temperature range of the fluid : Permissible range of the *fluid temperature* within which the apparatus can operate satisfactorily.

2.2.3.5 ambient temperature : Temperature of the environment in which the apparatus is working.

2.2.3.6 inlet temperature : *Fluid temperature* at the plane of the *inlet port.*

2.2.3.7 outlet temperature : *Fluid temperature* at the plane of the *outlet port.*

2.2.4 Pressure[1)]

2.2.4.1 nominal pressure.

2.2.4.2 working pressure : Pressure at which the apparatus is being operated in a given application.

2.2.4.3 working pressure range : Permissible range of *working pressure* within which the apparatus can operate satisfactorily.

2.2.4.4 inlet pressure; input pressure; supply pressure : Pressure at the apparatus *inlet port* measured under specified conditions.

2.2.4.5 outlet pressure; output pressure : Pressure at the apparatus *outlet port* measured under specified conditions.

2.2.4.6 pressure drop; differential pressure : Difference between *inlet* and *outlet pressure,* measured under specified conditions.

2.2.4.7 control pressure range : Range between highest and lowest permissible control pressure.

2.2.4.8 shock wave : Pressure pulse which moves at sonic speed in the liquid.

2.2.4.9 water-hammer : Pressure and depression waves created by relatively rapid flow changes and transmitted through the system.

2.2.4.10 surge : Temporary rise and fall of flow or pressure.

2.2.4.11 back pressure : Pressure due to downstream restrictions or due to change in the ratio of the *input* and *output impedance* in a device.

2.2.4.12 breakaway pressure; breakout pressure : Minimum pressure necessary to initiate movement.

2.2.4.13 burst pressure : Pressure which causes failure of and consequential fluid loss through the component envelope.

2.2.4.14 boost pressure; charge pressure : Pressure at which replenishing liquid is supplied (usually to closed loop transmissions or second stage pumps).

2.2.4.15 cracking pressure (deprecated term) : Pressure at which a pressure operated valve begins to pass fluid.

2.2.4.16 peak pressure : Pressure which may exceed the permitted maximum pressure for a relatively short time.

2.2.4.17 operating pressure : See *operating conditions.*

2.2.4.18 proof pressure : Test pressure, in excess of maximum *rated pressure,* which causes no permanent deformation, damage or malfunction.

2.2.4.19 shock pressure : Pressure existing in a *shock wave.*

[1)] Unless otherwise specified, gauge pressure is used in this International Standard.

2.2.4.20 static pressure : Pressure in a fluid at rest.

2.2.4.21 surge pressure : Pressure which results from a *surge.*

2.2.4.22 system pressure : Nominal pressure usually measured at the inlet to the first valve or at pump outlet (normally the relief valve setting).

2.2.4.23 pilot pressure : Pressure in a pilot line or circuit.

2.2.4.24 pre-charge pressure; inflation pressure : Gas pressure in an accumulator prior to admission of liquid.

2.2.4.25 suction pressure : Absolute fluid pressure at a pump inlet.

2.2.4.26 override pressure : For a pressure control valve, the pressure increase from a specified minimum flow to a specified operating flow.

2.2.4.27 rated pressure : See *rated conditions.*

2.2.4.28 critical pressure ratio : Value of the absolute upstream and downstream pressure ratio in a pneumatic device, at which the flow becomes sonic.

2.2.4.29 air consumption : Air volume required for the operation of a device or installation in order to perform a given task or for a stated time. Air volumes shall be expressed at *standard reference atmosphere conditions.* The symbol ANR follows the expression of the quantity.

2.2.4.30 theoretical air consumption : Theoretical volume of air required for the operation of a device or installation in order to perform a given task or for a stated time, the method of calculation being stated.

2.2.4.31 actual air consumption : Volume of air used in practice for the operation of a device or installation in order to perform a given task or for a stated period.

2.2.4.32 rated air consumption : Volume of air required for the operation of a device or installation under *rated conditions.*

2.2.4.33 rate of air consumption : *Air consumption* rate which corresponds to that defined in 2.2.4.29.

2.2.4.34 leakage : Flow leaking past *seals* doing no useful work.

2.2.4.35 internal leakage : *Leakage* between internal cavities of a device.

2.2.4.36 external leakage : *Leakage* from the interior of a device to atmosphere.

2.2.5 head : Height of a column or body of fluid above a datum expressed in linear terms (often used to express gauge pressure).

2.2.5.1 friction head : *Head* necessary to overcome fluid friction.

2.2.5.2 static head : Height of a column or body of liquid above a datum.

2.2.5.3 static discharge head : *Static head* from the centreline of a pump to the free discharge surface.

2.2.5.4 static suction head : *Static head* from the surface of a supply source to the centreline of a pump.

2.2.5.5 total static head : *Static head* from the surface of the supply source to the free discharge surface.

2.2.5.6 pressure head : Equivalent *head* of the liquid required to produce a given pressure.

2.2.5.7 velocity head : Equivalent *head* through which the liquid would have to fall to attain a given velocity.

2.2.5.8 lift : Height of a column or body of fluid below a given point expressed in linear units. Used to express pressures below atmospheric.

2.2.6 flow : Movement of fluid generated by pressure differences.

2.2.6.1 laminar flow : *Flow* state characterized by parallel or laminar movement of particles.

2.2.6.2 turbulent flow : *Flow* state characterized by random movement of particles.

2.2.6.3 cavitation : Formation of cavities, either gaseous or vapour, within a liquid stream, which occurs where the pressure is locally reduced to the vapour pressure of the liquid

2.2.6.4 flow rate : Quantity (volume or mass to be specified) of a fluid crossing the transverse plane of a *flow path* per unit time. Air volume rate shall be expressed at *standard reference atmospheric conditions.*

2.2.6.4.1 rated flow : *Flow rate* at the *rated conditions.*

2.2.6.4.2 supply flow : Flow of fluid through the *supply ports* of the device or system.

2.2.6.4.3 relief flow rate (pneumatic) : Rate at which air can flow through the unloading device for a specified increase in controlled pressure above the original setting, measured under specified conditions.

2.2.6.4.4 flow factor : Characterizes the *conductance* of a pneumatic or hydraulic device, flowline or connection.

2.2.6.4.5 flow parameters of pneumatic devices : Characterize the relations between the pressure and the flow in a compressible flow device

- *conductance;*
- *critical pressure ratio;*
- flow coefficient under subsonic state;
- flow coefficient under sonic state.

2.2.7 standard reference atmospheric conditions (ANR) : See ISO 558* and ISO 554**. The symbol ANR follows the expression of the quantity.

2.2.7.1 reference atmosphere : The agreed atmosphere to which test results determined in other atmospheres may be corrected if suitable correlation factors are available from established data.

2.2.8 Accuracy of regulation

2.2.8.1 hysteresis : Difference in controlled parameters, at the same control setting, when adjusting the quantity upwards and then downwards or vice versa.

2.2.9 Time

2.2.9.1 start-up time : Period of time needed to reach a *steady-state operating condition* in the system from "start up".

2.2.9.2 rise time : Time taken in a device for a quantity to change from a specified low level up to a specified high level.

2.2.9.3 fall time : Time taken in a device for a quantity to change from a specified high level down to a specified lower level.

2.2.9.4 Operation time

2.2.9.4.1 actuated time : Time during which the component is under the influence of the actuating forces.

2.2.9.4.2 released time : Time during which the component is not under the influence of the actuating force.

2.2.9.4.3 relative duty time, expressed as a percentage :

$$\frac{t\ (\text{actuated})}{t\ (\text{actuated}) + t\ (\text{released})} \times 100$$

2.2.9.5 response time : Time lapse between the initiation point of an operation and its point of completion, these points being defined for each type of component.

2.3 graphical representation : Diagrammatic means of conveying information about the function of components and circuits.

2.3.1 graphical symbol (schematic) : Formal, abstract design which represents the function of a component or group of components according to a standard or code.

2.3.1.1 symbols for hydraulic and pneumatic components : *Graphical symbols* for hydraulic and pneumatic equipment and accessories for fluid power transmission (see ISO 1219[1]).

2.3.1.2 symbols for fluid logic devices : *Graphical symbols* for fluid devices with and without moving parts used in logic circuits.

2.3.1.3 symbols for logic functions : *Graphical symbols* for logic and related functions in fluid logic circuits (RP 33).

2.3.1.4 cutaway symbol : *Graphical symbol* in the form of a simplified drawing showing the essential internal design features of a component.

2.3.1.5 pictorial symbol : *Graphical symbol* in the form of a simplified external picture of the component.

2.3.1.6 combination symbol : Symbol which combines *graphical, cutaway* and *pictorial symbols.*

---

* ISO 558, *Conditioning and testing — Standard atmospheres — Definitions.*

** ISO 554, *Standard atmospheres for conditioning and/or testing — Specifications.*

[1] ISO 1219, *Fluid power systems and components — Graphic symbols.*

2.3.2 diagram : Drawing which illustrates pertinent characteristics, locations, sizes, interconnections, controls, and actuation of components and circuits.

2.3.2.1 combination diagram : Drawing using a combination of *graphical, cutaway* and *pictorial symbols* with interconnecting lines.

2.3.2.2 cutaway diagram : Drawing using *cutaway symbols* with interconnecting lines.

2.3.2.3 graphical diagram; schematic : Drawing using *graphical symbols* and interconnecting lines, generally drawn according to a standard or other code.

2.3.2.4 pictorial diagram : Drawing using *pictorial symbols* and interconnecting lines.

2.3.2.5 circuit diagram : Drawing, using symbols, to represent the function of a *fluid power circuit* or part thereof.

2.3.2.6 pressure/time diagram : *Graphical representation* of pressure plotted against time, generally for a complete *cycle.*

2.3.2.7 function diagram : *Graphical representation* of the sequence of operations and control signals of a *fluid power circuit,* generally for a complete *cycle.*

2.4 Miscellaneous terms

2.4.1 cycle : One complete set of events or conditions, which repeats in an identical, i.e. cyclic, manner.

2.4.1.1 automatic cycle : *Cycle* of operations which, once started, repeats indefinitely until stopped.

2.4.1.2 manual cycle : *Cycle* which is always under human control.

2.4.1.3 semi-automatic cycle : *Cycle* which, after being started, completes one cycle and stops at the initial position.

2.4.1.4 working cycle : *Cycle* during which work is performed.

2.4.1.5 cycling speed : Number of *cycles* completed per unit of time under stated conditions.

2.4.1.6 maximum cycling speed : Maximum number of *cycles* per unit time under specified conditions.

2.4.2 phase : Distinct functional element of a *cycle.*

2.4.2.1 dwell phase : *Phase* where the specified action is stopped for a predetermined length of time.

2.4.2.2 working phase : *Phase* during which the work is accomplished.

2.4.2.3 neutral phase : Initial and ultimate *phase* of a *cycle.*

2.4.2.4 rapid advance phase : *Phase* of relatively high speed displacement toward the working position.

2.4.2.5 rapid return phase : *Phase* of relatively high speed displacement away from the working position.

2.4.3 life expectancy : Predicted working period during which a component or system will maintain a specified level of performance under specified conditions. Sometimes expressed in statistical terms as a probability.

2.4.4 power consumption : Total power consumed by the device or system under specified conditions.

2.4.5 frequency response; harmonic response : Changes, under *steady-state conditions,* in the output variable which are caused by a sinusoidal input variable.

2.4.6 repeatability[1] : Quantitative expression of the random error, associated with a single tester in a given laboratory, obtaining successive results with the same apparatus under constant operating conditions on identical test material.

2.4.7 reproducibility[1] : Quantitative expression of the random error, associated with testers working in different laboratories, each obtaining single results on identical test material when applying the same method.

2.4.8 drift : Change of a condition with time under steady-state operating conditions.

2.4.9 ripple : Periodic variation of a quantity above and below the operating value.

2.4.10 linearity : Maximum deviation between ideal linear and measured linear characteristic.

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[1] See ISO 3534, *Statistics — Vocabulary and symbols.*

2.4.11 linear region : Region of a given control characteristic over which the *linearity* remains within specified limits.

2.4.12 linear function : Describes a condition in which the relationship between two interdependent variables is constant.

2.4.13 hydraulic lock : Situation in which a quantity of trapped fluid prevents movement of a piston.

2.4.14 sticking : Locking of a piston or spool by unbalanced pressures in the clearance around the piston, which force it sideways causing sufficient friction to resist axial movement.

3 Energy conversion

3.0 General

3.0.1 Conditions of utilization (See 2.1.)

3.0.2 General characteristics

3.0.2.1 capacity; displacement : Volume absorbed or displaced per *stroke* or *cycle*.

3.0.2.1.1 effective capacity : Actual volume displaced under specified conditions.

3.0.2.1.2 geometric capacity : Volume displaced, calculated geometrically without reference to tolerances, clearances or deformation.

3.0.2.2 Power losses

3.0.2.2.1 volumetric losses :

1) Losses due to imperfect filling of the pumping chambers.
2) *Internal leakage.*
3) *External leakage.*
4) Volumetric *compressibility* losses.

3.0.2.2.2 hydrodynamic losses : Losses due to motion of the fluid.

3.0.2.2.3 mechanical losses : Losses due to mechanical friction.

3.0.2.3 Torque

3.0.2.3.1 derived torque : Torque corresponding to the derived fluid power.

3.0.2.3.2 geometric torque : Torque corresponding to the geometric fluid power.

3.0.2.3.3 effective torque : Actual torque transmitted by the shaft under specified conditions.

3.1 hydraulic pumps : Units which transform mechanical energy into hydraulic energy.

3.1.1 Types

3.1.1.1 rotodynamic pump : Pump in which the increase of fluid energy is derived from kinetic energy (the quantity of fluid delivered is related to the output pressure).

3.1.1.2 displacement pump : Pump in which the increase in fluid energy is derived from pressure energy (the quantity of fluid delivered is related to the *shaft speed*).

3.1.1.2.1 fixed displacement pump : Pump in which the fluid volume displaced per *cycle* (*capacity*) cannot be varied.

3.1.1.2.2 variable displacement pump : Pump in which the volume displaced per *cycle* can be varied.

3.1.1.2.2.1 control pump : Control applied to a positive displacement variable delivery pump to adjust the volumetric output or direction of flow.

3.1.1.3 rotary pump : Pump in which the pumping members deliver continuously while rotating about their axes (for example, a *gear pump*).

3.1.1.4 reciprocating pump : Pump in which the pumping members deliver in turn while stroking (for example, a *piston pump*).

3.1.1.5 gear pump : Pump in which two or more gears act in engagement as pumping members.

3.1.1.5.1 external gear pump : Pump with two or more external gears.

3.1.1.5.2 internal gear pump : Pump with an internal gear in engagement with one or more external gears.

3.1.1.5.3 fixed clearance gear pump : Pump in which the side clearance of the gears is fixed.

3.1.1.5.4 gear pump with pressure loading : Pump in which the side clearance of the gears is controlled as a function of the *outlet pressure*.

3.1.1.6 screw pump : Pump with one or more screws rotating in a body.

3.1.1.7 vane pump : Pump in which the fluid volume is displaced by a set of radial sliding vanes that contact a cam track and are driven by a rotor.

3.1.1.7.1 unbalanced vane pump : Pump in which the transverse forces on the rotor are not balanced.

3.1.1.7.2 balanced vane pump : Pump in which the transverse forces on the rotor are balanced.

3.1.1.8 piston pump : Pump in which the fluid volume is displaced by one or more reciprocating pistons.

3.1.1.8.1 radial piston pump : Pump having several pistons arranged to operate radially.

3.1.1.8.2 axial piston pump : Pump having several pistons with mutually parallel axes which are arranged around and parallel to a common axis. Pistons can be actuated by a swashplate or cam.

3.1.1.8.3 angled piston pump : *Axial piston pump* in which the drive shaft is at an angle to the common axis.

3.1.1.8.4 in-line piston pump : Pump having several pistons with mutually parallel axes arranged on a common plane.

3.1.1.9 hand-pump : Pump designed to be operated by hand.

3.1.1.9.1 single-acting hand-pump : *Hand-pump* in which the suction takes place during one part of the *cycle* and delivery during the remaining part of the cycle.

3.1.1.9.2 double-acting hand-pump : *Hand-pump* in which there are two alternate discharge strokes per *cycle.*

3.1.1.10 staged pump : Pump with pumping elements which operate in series.

3.1.1.11 multiple pump : Two or more pumps driven by a common shaft.

3.1.1.12 over-centre pump : Pump in which the direction of flow may be reversed without changing the *direction of rotation* of the drive shaft.

3.1.1.13 reversible pump : Pump in which the direction of flow may be reversed by changing the *direction of rotation* of the drive shaft.

3.1.1.14 uni-flow pump : Pump in which the direction of flow is independent of the *direction of rotation* of the drive shaft.

3.1.1.15 hydropneumatic pump : *Hydraulic pump* driven by compressed air; usually a continuous pressure intensifier.

3.1.2 Hydraulic pump characteristics

3.1.2.1 capacity (pump) : See 3.0.2.1.

3.1.2.1.1 derived capacity (pump) : Volume displaced at defined minimum *working pressure* calculated from two measurements at different *speeds.*

3.1.2.1.2 effective capacity : Quotient of effective *output flow* by the *rotational frequency.* See 3.0.2.1.1.

3.1.2.2 speed; rotational frequency : Number of revolutions per unit of time.

3.1.2.2.1 shaft speed : Number of revolutions of the shaft per unit of time.

3.1.2.2.2 reciprocating speed : Relates in general to *hand-pumps* and indicates the number of double strokes per unit of time.

3.1.2.3 output flow; outlet flow : *Flow rate* discharged at the *outlet port.*

3.1.2.3.1 geometric output flow : Product of the *geometric capacity* by the number of revolutions or *cycles* per unit of time.

3.1.2.3.2 derived output flow : Product of the *derived capacity* by the number of revolutions or *cycles* per unit of time.

3.1.2.3.3 effective output flow : Actual *output flow* at the pump outlet measured at the pressure and temperature at that point.

3.1.2.4 hydraulic power (pump) : Increase of hydraulic energy per unit time between *inlet* and *outlet ports* of the pump.

3.1.2.4.1 geometric hydraulic power : *Hydraulic power* calculated from the *geometric output flow.*

3.1.2.4.2 derived hydraulic power : *Hydraulic power* calculated from the *derived output flow.*

3.1.2.4.3 effective hydraulic power : *Hydraulic power* calculated from the *effective output flow.*

3.1.2.5 input power : Power applied to the driving shaft.

3.1.2.5.1 absorbed power : Power absorbed at the drive shaft of the pump at a given instant or under given load conditions.

3.1.2.5.2 required power : Power which is necessary to drive the pump shaft under specified conditions.

3.1.2.5.3 installed power : Rated power of the driving motor.

3.1.2.6 torque (pump) : Torque transmitted to the drive shaft of the pump

- *derived torque;*
- *geometric torque;*
- *effective torque.*

3.1.2.7 losses (pump) : Portion of the absorbed power not transformed into fluid power

- *volumetric losses;*
- *hydrodynamic losses;*
- *mechanical losses.*

3.1.2.8 Efficiency (pump)

3.1.2.8.1 volumetric efficiency : Ratio of the *effective output flow* to the *derived output flow.*

3.1.2.8.2 hydromechanical efficiency : Ratio of *derived torque* to absorbed hydraulic torque.

3.1.2.8.3 overall efficiency : Ratio of the *effective hydraulic power* to absorbed hydraulic power.

3.1.3 Installation

3.1.3.1 mounting : Method of supporting unit.

3.1.3.1.1 flange mounting : Mounted by a flange with the supporting face at right angles to the drive shaft.

3.1.3.1.2 spigot pilot location : Unit located by a spigot, however mounted.

3.1.3.1.3 foot mounting : Mounting with the supporting face parallel to the drive shaft.

3.1.3.2 shaft extension : That part of the drive shaft which extends outside the unit and which includes the means whereby the drive is effected; for example, key, taper spline, etc.

3.1.3.3 connection : See 4.0.3.

3.2 Motors

3.2.0 Motors in which the direction of rotation of the output may be changed with or without changing the direction of the input flow

3.2.0.1 over-centre motor : Motor in which the *direction of rotation* of the output may be changed without changing the direction of the *input flow.*

3.2.0.2 reversible motor : Motor in which the *direction of rotation* of the output may be reversed by changing the direction of the *input flow.*

3.2.1 air motors : Units which convert pneumatic energy into mechanical energy.

3.2.1.1 piston air motor : Motor which usually has several pistons driving a shaft. Pressure acts successively on each piston through a valve gear governed by the rotation of the motor.

3.2.1.2 vane air motor : Motor consisting of a stator and a rotor with grooves parallel to the axis of rotation mounted eccentrically within the stator. Air pressure acts on the vanes which slide in the grooves.

3.2.2 hydraulic motors : Units which transform hydraulic energy into mechanical energy, usually with a rotary output.

3.2.2.1 Types

3.2.2.1.1 displacement motor : Motor in which the quantity of fluid absorbed is related to *shaft speed.*

3.2.2.1.2 rotary motor : Motor in which the working members convert hydraulic energy continuously while rotating about their axes.

3.2.2.1.3 reciprocating motor : Motor in which the working members reciprocate.

3.2.2.1.4 fixed displacement motor : Motor in which the volume displaced per *cycle* (*capacity*) cannot be varied.

3.2.2.1.5 variable displacement motor : Motor in which the volume displaced per *cycle* (*capacity*) can be varied.

3.2.2.1.6 gear motor : Motor in which two or more gears act in engagement as working members.

3.2.2.1.6.1 external gear motor : Motor with two or more external gears.

3.2.2.1.6.2 internal gear motor : Motor with an internal gear in engagement with one or more external gears.

3.2.2.1.6.3 fixed clearance gear motor : Motor in which the side clearance of the gears is fixed.

3.2.2.1.6.4 gear motor with pressure loading : Motor in which the side clearances of the gears are controlled as a function of the *inlet pressure.*

3.2.2.1.7 vane motor : Motor in which the fluid under pressure acting on a set of radial vanes causes rotation of an internal member.

3.2.2.1.7.1 unbalanced vane motor : Motor in which the transverse forces acting on the rotor are not balanced.

3.2.2.1.7.2 balanced vane motor : Motor in which the transverse forces on the rotor are balanced.

3.2.2.1.8 Piston motors

3.2.2.1.8.1 radial piston motor : Motor having several pistons arranged to operate radially.

3.2.2.1.8.2 axial piston motor : Motor having several pistons with mutually parallel axes which are arranged around and parallel to a common axis.

3.2.2.1.9 multiple motor : Two or more motors having a common shaft.

3.2.2.1.10 linear motor : *Cylinder* (see 3.5).

3.2.2.1.11 hydraulic stepping motor : *Hydraulic motor* which follows the commands of a stepped input signal to achieve positional accuracy.

3.2.2.1.12 semi-rotary actuator : *Hydraulic motor* in which the angle of rotation of the shaft is limited.

3.2.2.2 Hydraulic motor characteristics

3.2.2.2.1 capacity (motor) : See 3.0.2.1.

3.2.2.2.1.1 derived capacity (motor) : Volume absorbed at defined minimum *working pressure* obtained from measurements at two different *speeds.*

3.2.2.2.2 Speed

3.2.2.2.2.1 shaft speed; rotational frequency : See 3.1.2.2.

3.2.2.2.2.2 slip : Difference between *shaft speeds* at specified *input flow* and under different loading conditions.

3.2.2.2.3 input flow; inlet flow : *Flow rate* crossing the transverse plane of the *inlet port.*

3.2.2.2.3.1 geometric input flow : Product of the *geometric capacity* and the number of revolutions per unit time.

3.2.2.2.3.2 derived input flow : Product of the *derived capacity* and the number of revolutions per unit time.

3.2.2.2.3.3 effective input flow : Actual flow at the inlet measured at the pressure and temperature at that point.

3.2.2.2.4 output power (motor) : Mechanical power transmitted by the shaft of the motor.

3.2.2.2.4.1 hydraulic power (motor) : Decrease in hydraulic energy per unit time between the inlet and outlet of the motor.

3.2.2.2.4.2 geometric hydraulic power : *Hydraulic power* calculated from the *geometric capacity.*

3.2.2.2.4.3 derived hydraulic power : *Hydraulic power* calculated from the *derived capacity.*

3.2.2.2.4.4 effective hydraulic power : *Hydraulic power* calculated from the *effective capacity.*

3.2.2.2.5 torque (motor) : Torque transmitted by the shaft of the motor

- *derived torque;*
- *geometric torque;*
- *effective torque.*

3.2.2.2.5.1 starting torque : Minimum torque available at the motor shaft when starting from rest for a given pressure differential under specified conditions.

3.2.2.2.6 losses (motor) : Portion of the *effective hydraulic* (input) *power* not transformed into *output power*

- *volumetric losses;*
- *hydrodynamic losses;*
- *mechanical losses.*

3.2.2.2.7 Efficiency (motor)

3.2.2.2.7.1 volumetric efficiency : Ratio of the *derived input flow* and the *effective input flow.*

3.2.2.2.7.2 hydromechanical efficiency : Ratio of the *effective torque* and *derived torque.*

3.2.2.2.7.3 overall efficiency : Ratio of the *output power* to the *effective hydraulic power.*

3.2.2.3 Installation (see 3.1.3 to 3.1.3.3)

3.3 hydraulic pump-motor : Unit which functions either as a pump or as a rotary motor.

3.3.1 fixed capacity pump-motor : Pump-motor which is of fixed displacement design (see 3.1.1.2.1).

3.3.2 variable capacity pump-motor : Pump-motor which is of variable displacement design (see 3.1.1.2.2).

3.4 Variable speed drive units (integral transmissions)

3.4.1 variable speed drive units; integral transmissions : Combination of one or more *hydraulic pumps* and *motors* forming a unit designed to obtain a variation of speed or torque.

3.4.1.1 stiffness : Ratio of the variation of torque applied to a shaft and the variation of the angular position of the shaft.

3.4.1.2 zero position : Pump in zero *capacity* position.

3.4.1.3 neutral position (motor) : Motor adjusted to zero *capacity* position.

3.4.1.4 free position : Pump and motor are both in zero *capacity* position.

3.5 cylinder : Device which converts fluid energy into linear mechanical force and motion.

3.5.0 General

3.5.0.1 rod end; front end; End of the *cylinder* through which the piston rod passes.

3.5.0.2 rear end; head end : Closed end of the *cylinder.*

3.5.0.3 extend [out] stroke : Outward movement of the piston rod.

3.5.0.4 retract [in] stroke : Inward movement of the piston rod.

3.5.0.5 cushioning : Means whereby the piston is decelerated as it approaches the end of its *stroke.* May be either fixed or adjustable.

3.5.0.6 mechanical cushioning : *Cushioning* achieved by friction or by use of a resilient material.

3.5.0.7 fluid cushioning : *Cushioning* achieved by throttling the rate of exhaust (return).

3.5.0.8 length of cushion : Distance between the point at which *cushioning* begins and the end of the *stroke.*

3.5.1 Functional measurements

3.5.1.1 cylinder bore : Internal diameter of the cylinder body.

3.5.1.2 effective piston area : Area upon which fluid pressure acts to provide a mechanical *force.*

3.5.1.3 piston rod area : Cross-sectional area of the piston rod.

3.5.1.4 effective rod end area : Effective annulus area between the bore and the piston rod diameter.

3.5.1.5 port connections : See 5.2.4.

3.5.1.6 stroke : Distance travelled by the piston in moving from one extreme position to another.

3.5.1.7 working stroke : Distance travelled by the piston in moving between two defined positions during actual operation.

3.5.1.8 swept volume : Volume of a theoretically incompressible fluid that would be displaced by the piston during a complete *stroke.* (For *double-acting cylinders,* it shall be given for both directions of stroke.)

3.5.2 working cycle : See 2.4.1.4.

3.5.3 Characteristics

3.5.3.1 Pressure

3.5.3.1.1 cylinder pressure : Static pressure at a stated point in actual operation.

3.5.3.1.2 induced pressure : Pressure generated by an externally applied *force.*

3.5.3.1.3 damping pressure : Pressure generated by the damping device to decelerate the total moving mass (see *cushioning*).

3.5.3.1.4 intensified pressure (rod end) : Pressure generated with rod end outlet flow restricted and *cylinder* extending under pressure.

3.5.3.2 force : Force transmitted by the piston rod.

3.5.3.2.1 theoretical force : Pressure multiplied by the *effective piston area,* ignoring friction. For *double-acting cylinders,* the value shall be given for both directions of *stroke.*

3.5.3.2.2 nominal force : *Force* exerted by the piston rod allowing for all frictional losses when the cylinder is operating under standard conditions. For *single-acting cylinders* with a return spring, the value shall be given at both beginning and end of the *stroke.*

3.5.3.2.3 actual force : *Force* actually transmitted by the piston rod.

3.5.3.3 cylinder capacity; cylinder displacement : See 3.0.2.1.

3.5.3.3.1 extending capacity; extending displacement : Volume required for one full extension of a cylinder.

3.5.3.3.2 retracting capacity; retracting displacement : Volume (annular) absorbed by one full retraction of the cylinder.

3.5.3.4 Fluid volume

3.5.3.4.1 Hydraulic fluid volume

NOTE — Hydraulic fluid volumes are to be stated as for atmospheric pressure and ambient temperature.

3.5.3.4.1.1 theoretical oil volumes; geometric cylinder capacity : Theoretically calculated *hydraulic fluid volume* used for a *working cycle*.

3.5.3.4.1.2 actual hydraulic fluid volume; effective cylinder capacity : *Hydraulic fluid volume* actually used for a *working cycle* when the *cylinder* is operating in a given working cycle.

3.5.3.4.1.3 rated hydraulic fluid volume : *Hydraulic fluid volume* used in a *working cycle* when the *cylinder* operates under *rated conditions*.

3.5.3.4.1.4 mean rate of hydraulic fluid flow : *Hydraulic fluid volume* absorbed during a *working cycle* divided by the time taken. For *double-acting cylinders*, this includes both directions of motion.

3.5.3.5 leakage : See 2.2.4.34.

3.5.3.5.1 internal leakage flow : See 2.2.4.35.

3.5.3.5.2 external leakage flow : See 2.2.4.36.

3.5.3.6 Power

3.5.3.6.1 input power : Decrease in fluid energy per unit time between the inlet and outlet of the *cylinder*. In the case of a *single-acting cylinder*, this is the total energy at the inlet.

3.5.3.6.2 output power, mechanical : Mechanical power transmitted by the piston rod.

3.5.3.7 overall efficiency (cylinder) : Ratio between *mechanical output power* and *input power*.

3.5.3.7.1 thrust efficiency : Ratio between the effective *force* and the *theoretical force*.

3.5.3.7.2 speed efficiency : Ratio between the effective piston speed and the theoretical speed.

3.5.3.8 Time

3.5.3.8.1 time of outward stroke : Time from commencement of movement to the completion of the outward stroke measured under "no load" or specified load conditions.

3.5.3.8.2 time of return stroke : Time from commencement of movement to the completion of the inward stroke, measured under "no load" or specified conditions.

3.5.3.8.3 cylinder response time : See 2.2.9.5. The initiation point is the start of pressure increase; the completion point is the start of piston movement. The measurements are made under *rated conditions*, either unloaded or for stated conditions.

3.5.4 Types

3.5.4.1 piston type cylinder : *Cylinder* in which the mechanical force is produced by fluid pressure acting on a piston.

3.5.4.2 diaphragm type cylinder : *Cylinder* in which the mechanical force is produced by fluid pressure acting on a diaphragm.

3.5.4.3 single-acting cylinder : *Cylinder* in which displacement in one direction is by fluid force and in the other by another force.

3.5.4.3.1 single-acting, spring return cylinder : *Single-acting cylinder* returned by a spring.

3.5.4.3.2 single-acting, gravity return cylinder : *Single-acting cylinder* returned by gravity.

3.5.4.4 double-acting cylinder : *Cylinder* in which the forward and return strokes are effected by fluid pressure.

3.5.4.5 single rod cylinder : *Cylinder* with piston rod extending from one end.

3.5.4.6 double rod cylinder : *Cylinder* with piston rod extending from both ends (double-ended).

3.5.4.7 differential cylinder : *Double-acting cylinder* in which the ratio of the area of the bore to the annular area between the bore and the piston rod is significant in circuit function.

3.5.4.8 duplex cylinder : Unit comprising two *cylinders* with independent control, mechanically connected on a common axis to provide three or four positions depending on the method of application.

3.5.4.9 multi-position cylinder : Arrangement of at least two pistons on the same axis, moving within a common *cylinder* body divided into several independently controlled chambers, to permit the selection of a variety of positions.

3.5.4.10 tandem cylinder : Arrangement of at least two pistons on the same rod moving in separate chambers on the same cylinder body allowing the compounding of *force.*

3.5.4.11 telescopic cylinder : *Cylinder* with two or more stages of extension, achieved by hollow piston rods sliding one within the other.

3.5.5 mounting : Method by which the *cylinder* is secured.

3.5.5.1 side mounting : All methods of *mounting* on a surface parallel to the axis of the *cylinder.*

3.5.5.1.1 angle mounting : *Cylinder* secured by bracket or brackets of angular construction.

3.5.5.1.2 tapped holes mounting : *Mounting* consisting of one or more tapped holes within the *cylinder* profile.

3.5.5.1.3 foot mounting : *Mounting* consisting of projections (feet) beyond the cylinder profile, permitting it to be attached to a face parallel to the cylinder axis.

3.5.5.2 transverse mounting : All methods of *mounting* defined by a plane at right angles to the axis of the *cylinder.*

3.5.5.2.1 eye mounting : *Mounting* consisting of a projection to the cylinder construction extending beyond the *cylinder* profile to permit mounting by means of a pin passing through the projection at right angles to the cylinder axis.

3.5.5.2.2 cylinder flange mounting : *Mounting* consisting of a suitably shaped plate or collar usually extending beyond the *cylinder* profile, secured to or forming part of the cylinder (it is usually provided with suitable holes for fixing).

3.5.5.2.3 threaded end mounting : *Mounting* by means of threaded projections or recesses coaxial with *cylinder* axis to permit mounting.

3.5.5.2.4 tie rod mounting : *Mounting* by means of rods parallel to and outside the *cylinder* body, which clamp together the cylinder heads and barrel, extensions of which may be used to mount the cylinder at one or both ends.

3.5.5.2.5 neck [nose] mounting : Threaded projection coaxial with the *cylinder* axis at the rod end to permit *mounting.*

3.5.5.3 pivot mounting : All methods of *mounting* which permit angular movement of the *cylinder.*

3.5.5.3.1 clevis mounting : U-shaped mounting device which accepts a lug and through which a pin or bolt passes, to make a *pivot mounting.*

3.5.5.3.2 pin mounting : Mounting device consisting of an extension lug containing a pivot pin hole.

3.5.5.3.3 trunnion mounting : Mounting device consisting of a pair of male or female pivots on opposite sides of the *cylinder* the axis of which intersects the cylinder axis at right angles.

3.5.5.3.4 spherical mounting : Arrangement swivelling round a point allowing angular movement of the *cylinder* in any plane including its axis.

3.5.6 piston rod attachment : Method by which the piston rod transmits force, for example threaded, plain, eye, clevis.

3.6 pressure intensifier : Device which converts the working pressure in one fluid (primary) system into a higher working pressure in a separate fluid system (secondary). The two fluid systems may employ similar or different fluids.

3.6.0 General

3.6.0.1 primary fluid : Descriptive of fluid at low pressure applied to the *inlet port* of the *pressure intensifier,* and of anything concerned with the fluid : flow, pressure, circuit.

3.6.0.2 secondary fluid : Descriptive of fluid at high pressure applied to the *outlet port* of the *pressure intensifier,* and of anything concerned with the fluid : flow, pressure, circuit.

3.6.0.3 ratio of intensification : The ratio of the secondary pressure to the primary pressure or of the primary *flow rate* to the secondary flow rate.

3.6.1 Types

3.6.1.1 single fluid intensifier : Intensifier in which a fluid of similar type is used in both primary and secondary circuits.

3.6.1.2 dual fluid intensifier : Intensifier in which different types of fluid are used in the primary and secondary circuits.

3.6.1.3 single-acting intensifier : Unit which only intensifies the fluid pressure in one direction of flow of the *primary fluid.*

3.6.1.4 double-acting intensifier : Unit which intensifies the *secondary fluid* pressure whatever the direction of flow of the *primary fluid.*

3.6.1.5 single shot intensifier : Intensifier in which the continuous application of *primary fluid* at the *inlet port* can only give a limited volume of *secondary fluid.*

3.6.1.6 continuous intensifier : Intensifier in which continuous application of *primary fluid* to the *inlet port* can produce a continual flow of *secondary fluid.*

3.7 pneumatic-hydraulic actuator : Device in which power is transferred from one medium (pneumatic) to another (hydraulic) without intensification.

3.8 dashpot : Hydraulic damping device which acts as a variable speed regulator for a pneumatic *cylinder.*

4 Energy control and regulation

4.0 valve : Device which regulates the direction, pressure and flow of fluid used in *fluid power circuits.*

4.0.1 flow path : See 5.2.3.

4.0.2 sub-plate; sub-base : Mounting to which a single *sub-plate valve* is fitted and which includes external ports for pipe connections.

4.0.2.1 multiple sub-plate : Mounting to which several *sub-plate valves* are fitted and which include external ports for pipe connections.

4.0.2.2 ganged sub-plates : Similar *sub-plates* of which two or more can be clamped together by tie bolts or other means. It can be arranged for the mating faces of the sub-plates to have matching ports, thus providing for a common supply and/or exhaust system. The sub-plates incorporate the various ports for connection of the external pipelines.

4.0.2.3 manifold block : Base which forms the *sub-plate* for two or more sub-plate mounted valves, incorporating the various *port connections* for the external pipelines. It can also embody flow paths for interconnecting the various valves mounted thereon.

4.0.3 connections : *Threaded ports,* flanges or similar means for connecting to the pipelines (see 5.2.2 to 5.2.4).

4.0.4 Types of valve mounting

4.0.4.1 mono-block valve : Unit comprising a number of similar valves in a common housing.

4.0.4.2 sub-plate valve : Valve that can operate only in conjunction with an associated mounting plate or housing incorporating the necessary *ports* to which it is connected.

4.0.4.3 ganged valve; sandwich valve : Unit consisting of an assembly of a number of similar valves banked together, often with common supply and/or exhaust systems.

4.0.4.4 cartridge valve : Valve with working parts contained in a cylindrical body; the *ports* of which coincide with ports in the containing housing.

4.0.4.5 pilot valve : A valve which operates another valve or control.

4.0.5 controls : See clause 6.

4.0.6 flow rate : See 2.2.6.4.

4.0.7 Time

4.0.7.1 valve response time : See 2.2.9.5. The initial point is the moment when the *pilot pressure* rises/falls past a given point; the completion point is when a given value of the *outlet pressure* or flow has been reached.

4.0.7.1.1 dead time of a pneumatic directional control valve with pneumatic control : See 2.2.9.5. The initial point is the moment when the *pilot pressure* rises/falls past a given level; the completion point is the moment when the *outlet pressure* reaches a specified percentage of its maximum, the outlet being connected to zero capacity (*outlet port* closed).

4.0.7.1.2 dead time of a pneumatic directional control valve with electrical control : See 2.2.9.5. The initial point is the opening (or closing) of the electrical circuit; the completion point is the moment when the *outlet pressure* reaches a specified percentage of its maximum, the outlet being connected to zero capacity (*outlet port* closed).

4.0.7.1.3 switching time : See 4.0.7.1. Switch-on time for an output going from the 0-state to the 1-state; switch-off time for an output going from the 1-state to the 0-state.

4.0.8 Switching

4.0.8.1 switching pressure : Minimum *pilot pressure* necessary to cause a change of state at an *output port.*

4.0.8.2 switching time : See 2.2.9.5. The initial point is the moment when the *control* or *pilot pressure* reaches the level of *switching pressure;* the completion point is when a given value of the *outlet pressure* has been reached.

4.0.8.3 switching power : Minimum power at the *control port* that will operate the device.

4.0.8.4 switching characteristic : Curve expressing output quantity as a function of control quantity.

4.0.9 amplification : Ratio between the output signal variations and the control signal variations (for analogue devices only).

4.0.9.1 power amplification : The ratio between the *output power* variation and the corresponding *input* (control) *power* variation (for analogue devices only).

4.0.9.2 pressure amplification (linear devices) : Ratio between the *outlet pressure* and the *inlet* (control) *pressure.*

4.0.9.3 flow amplification : Ratio between the *output flow* and the *input* (control) *flow.*

4.0.10 minimum control flow : Flow through the control port at minimum *control pressure.*

4.0.11 steady-state supply pressure range : Region between the permitted limits of the *supply pressure.*

4.0.12 transient recovery time : Period of time required for a step input change in the pressure to damp out to within the desired operating band.

4.0.13 pressure regulation characteristics : Change of the specified controlled pressure due to a change of the *inlet pressure,* measured at a specified *flow rate.*

4.0.14 flow/pressure characteristics : Change of the specified controlled pressure due to change in the *flow rate* of the fluid, measured at specified pressure conditions.

4.1 directional control valve : Device connecting o isolating one or more *flow paths.*

4.1.1 Types

4.1.1.1 slide valve : *Valve* in which the *flow paths* are connected or isolated by means of a movable sliding member. The movement may be axial, rotary or both.

4.1.1.1.1 flat slide valve : *Valve* in which the *flow paths* are connected or isolated by means of a flat-faced valve member which slides on a flat seat.

4.1.1.1.2 spool valve : *Valve* in which the *flow paths* are connected or isolated by a cylindrical sliding member positioned within the matching bore of the valve body.

4.1.1.2 poppet valve : *Valve* in which the *flow paths* are opened or closed as the valve element (poppet) is lifted or seated.

4.1.2 valving element : That component of a *valve* which, by its movement, provides the basic function of directional control, pressure control or flow control.

4.1.2.1 valve element positions : Positions of the valving element which control the basic function.

4.1.2.2 normal position : Position of the valving element after removal of the actuating *forces* or control signals.

4.1.2.3 initial position : Position of the valving element after main pressure is admitted and before the intended operating *cycle* begins under the influence of the actuating *forces.*

4.1.2.4 middle [neutral] position : Central position of a three-position valve.

4.1.2.5 actuated position : Final position of the valving element when under the influence of the actuating forces.

4.1.2.6 intermediate position : Any position between the *initial* and the *actuated position.*

4.1.2.7 closed position : Valve position in which the inlet supply is not connected to an outlet.

4.1.2.8 open position : Valve position in which the inlet supply is connected to an outlet.

4.1.2.9 closed centre position : Position in which all *ports* are closed when the control member is in the *neutral position.*

4.1.2.10 open centre position : Position in which *supply* and *return ports* are connected and the service ports closed.

4.1.2.11 float position : Position in which all *service ports* are connected to return.

4.1.2.12 fully by-passing position : Position in which all ports are connected to return.

4.1.3 spring return; spring offset : See 6.3.2.

4.1.4 fluid return; pressure offset : See 6.4.

4.2 check valves; non-return valves : Valves which allow flow in one direction only.

4.2.1 Types

4.2.1.1 spring-loaded check valve : *Check valve* in which the element is held closed by means of a spring thus permitting mounting in any attitude.

4.2.1.2 pilot-controlled check valve : *Check valve* in which the opening or closing is controlled by a pilot signal.

4.2.1.3 cushioned check valve : *Check valve* in which the movement of the check device is damped, for use in systems with pulsating pressures.

4.2.1.4 prefill valve : *Valve* which permits full flow from a reservoir to a working *cylinder* during the advance phase of a *cycle,* permits the *operating pressure* to be applied during the *working phase* and permits free flow from the cylinder to the reservoir during the return phase.

4.2.2 shuttle valve : *Valve* with two inlets and a common outlet. The outlet is automatically connected to one or other of the inlets by the action of the inlet pressures.

4.2.2.1 high pressure shuttle valve : *Valve* in which the inlet at higher pressure is connected to the outlet, the other inlet being closed. The position is maintained under reverse flow.

4.2.2.2 low pressure shuttle valve : *Valve* in which the inlet at lower pressure is connected to the outlet, the other inlet being closed. The position is maintained under reverse flow.

4.2.3 quick exhaust valve : *Valve* in which, when air pressure falls at the inlet, the outlet is automatically opened to exhaust.

4.2.4 automatic shut-off valve; maximum flow control valve : *Valve* designed to close automatically when the pressure drop across the valve, caused by increased flow, exceeds a predetermined amount.

4.3 pressure control valve : *Valve* the essential function of which is to regulate pressure.

4.3.0 General

4.3.0.1 pressure relief valve : *Valve* which limits maximum pressure by exhausting fluid when the required pressure is reached.

4.3.0.2 sequence valve : *Valve* in which, when the *inlet pressure* exceeds the preset value, the valve opens to permit flow through the *outlet port.* (The effective setting is not affected by the pressure on the outlet port.)

4.3.0.3 pressure regulator; pressure-reducing valve : *Valve* in which, with varying *inlet pressure* or outlet flow, the *outlet pressure* remains substantially constant. Inlet pressure shall, however, remain higher than the selected outlet pressure.

4.3.0.3.1 proportional pressure-reducing valve : *Valve* in which the *outlet pressure* is maintained at a fixed ratio to the *inlet pressure.*

4.3.0.3.2 relieving pressure regulator : *Pressure regulator* equipped with an unloading device to prevent the *outlet pressure* exceeding the original setting.

4.3.0.3.3 counterbalance valve : *Pressure control valve* which maintains *back pressure* to prevent a load from falling.

4.3.0.3.4 decompression valve : *Pressure control valve* which controls the rate at which the energy of compressed fluid is released.

4.3.0.3.5 surge damping valve : *Valve* which reduces shock by limiting the rate of acceleration of fluid flow.

4.3.0.4 unloading valve : *Valve* which opens an outlet to permit free flow to reservoir (or pneumatic exhaust).

4.3.1 Types

4.3.1.1 poppet type : *Valve* in which the pressure is controlled by *forces* acting on a poppet.

4.3.1.2 diaphragm type : *Valve* in which the pressure is controlled by *forces* acting on a diaphragm.

4.3.1.3 piston type : *Valve* in which the pressure is controlled by *forces* acting on a piston.

4.3.1.4 directly operated type : *Valve* in which the controlling *forces* acting on the element directly influence the movement of the control elements.

4.3.1.5 (indirect) pilot-operated type : *Valve* in which a relatively small flow through an integral vent line relief (pilot) controls the movement of the main element.

4.3.1.6 mechanically controlled type : *Valve* in which the *force* acting on the control element is a spring or weight. In the case of the spring, the spring force is normally applied manually.

4.3.1.7 pilot-controlled type : *Valve* in which the control element is influenced by a controlling fluid pressure.

4.3.1.8 manually operated type : *Valve* in which the controlling force acting on the control element or piston is manually applied.

4.3.1.9 bi-directional relief valve : *Valve* having two *ports* either of which can be used as the inlet when the other will become the outlet without making any physical change or adjustment to the valve.

4.4 flow control valves : *Valves* the main function of which is to control the *flow rate*.

4.4.1 Types

4.4.1.1 fixed restrictor valve : *Valve* in which the *inlet* and *outlet ports* are interconnected through a restricted passageway the cross-sectional area of which cannot be altered.

4.4.1.2 adjustable restrictor valve : *Valve* in which the *inlet* and *outlet ports* are interconnected through a restricted passageway the cross-sectional area of which can be varied within limits.

4.4.1.3 deceleration valve : *Flow control valve* which gradually reduces *flow rate* to provide deceleration.

4.4.1.4 one-way restrictor valve : *Valve* which allows free flow in one direction and restricted flow in the other direction. Restricted *flow path* may be fixed or variable.

4.4.1.5 series flow control valve : Pressure-compensated *flow control valve* which regulates the flow passing through it, usually in one direction only.

4.4.1.6 bypass flow control valve : Pressure-compensated *flow control valve* which regulates the working flow diverting surplus fluid to reservoir or to a second service.

4.4.1.7 flow divider valve : Pressure-compensated *valve* which divides *input flow* rate into two separate *output flow* rates of selected ratio.

4.4.1.8 flow-combining valve : Pressure-compensated *valve* which combines two *input flow* rates maintaining a preselected output.

4.5 shut-off [isolating] valve : Two-way *valve* which can permit or prevent flow in either direction.

4.5.1 Types

4.5.1.1 plug valve : *Shut-off valve* in which ports are connected or sealed off by a rotating plug containing *flow paths*.

4.5.1.1.1 tapered plug valve : *Plug valve* in which the surface of contact between the plug and the valve body is tapered and provides the sealing surface.

4.5.1.1.2 cylindrical plug valve : *Plug valve* in which the surface of contact between the plug and the valve body is cylindrical and requires a method of sealing.

4.5.1.1.3 spherical plug valve : *Plug valve* in which the surface of contact between the plug and the valve body is spherical and requires a method of sealing.

4.5.1.2 slide shut-off valve : *Shut-off valve* in which the *flow paths* are connected together or sealed off by means of a movable sliding member. The movement may be axial, radial or both.

4.5.1.2.1 flat slide shut-off valve : *Shut-off valve* in which the *flow paths* are connected together or sealed off by means of a movable flat-faced valve member sliding on a flat seat.

4.5.1.2.2 spool shut-off valve : *Shut-off valve* in which the *flow paths* are connected or sealed off by a cylindrical spool which slides within the matching bore of the valve body.

4.5.1.3 globe valve : *Shut-off valve* in which the flow at one point is at right angles to the normal direction of flow. The valve member is a flat disc which is lifted or seated to open or close the *flow path.*

4.5.1.4 needle valve : *Shut-off valve* in which the adjustable control element is a tapered needle. Its normal purpose is the accurate control of the rate or volume of flow.

4.5.1.5 gate valve : Straight-through *shut-off valve* in which the valve element moves perpendicularly to the axis of the flow to control opening and closing.

4.5.1.6 diaphragm valve : *Shut-off valve* in which opening and closing is controlled by the deformation of a diaphragm.

4.5.1.7 pinch valve : Straight-through *shut-off valve* in which the valve element consists of a flexible sleeve which is distorted to control the flow of the fluid.

4.5.1.8 butterfly valve : Straight-through *shut-off valve* in which the valve element consists of a flat disc rotating about a diametrical axis perpendicular to the flow of fluid.

4.5.1.9 closed position : Position of the valve member in which the *flow path* between *inlet* and *outlet ports* is closed.

4.5.1.10 open position : Position of the valve member in which the *flow path* between *inlet* and *outlet ports* is open (full or partial opening).

4.6 Fluid logic and fluid analogue devices

4.6.0 General

For general terms and mathematical definitions applied in other technologies as well as in fluid power, which have been standardized or are based on existing IEC or ISO standards, reference is made to the related standards and documents mentioned below.

> ISO 2382/1, *Data processing — Vocabulary — Section 01 : Fundamental terms.*
>
> IEC Publication No. 50(37), *International Electrotechnical Vocabulary — Group 37 : Automatic controlling and regulating systems.*

4.6.1 General terms and definitions

Definitions and terms related to the design and engineering of fluid logic circuits.

4.6.1.1 monostable : Binary circuit or device, which has one stable state and which requires an appropriate change of the input to cause a transition out of its stable state for a specified period of time. The specified period of time at which the circuit stays out of its stable state is independent of the duration of the appropriate change of the input signals.

4.6.1.2 unistable : Binary circuit or device, which has one stable state and in which the output changes state for the duration of the appropriate change of the input signal.

4.6.1.3 bistable : Binary circuit or device which has two stable states and which in each state requires an appropriate impulse to cause a transition to the other state.

4.6.1.4 fluid logic : Branch of fluid power associated with digital signal sensing and information processing, using components with or without moving parts.

4.6.1.5 fluidics : Signal sensing and information processing or energy control with fluid using components without moving parts.

4.6.1.6 moving part logic : Fluid logic using components with moving parts.

4.6.1.7 digital fluidics : That section of *fluidics* which deals with digital data.

4.6.1.8 laminar flow : See 2.2.6.1.

4.6.1.9 turbulent flow : See 2.2.6.2.

4.6.1.10 vortex : Spiral motion of a fluid resulting in a radial pressure gradient. The trajectories are curves which encircle a single line (axis).

4.6.1.11 fluid resistance : Ratio between *pressure drop* and steady-state mass flow.

4.6.1.12 fluid impedance : Complex ratio between *pressure drop* and transient mass flow.

4.6.1.13 fluid conductance : Ratio between steady-state mass flow and *pressure drop* (reciprocal value of *fluid resistance*).

4.6.1.14 inductive impedance : Imaginary ratio of *pressure drop* and transient mass flow in which pressure drop leads flow by phase.

4.6.1.15 capacitive impedance : Imaginary ratio of *pressure drop* and transient mass flow in which pressure drop leads flow.

4.6.1.16 fluid inductance : Ratio of *pressure drop* to rate of change of mass flow.

4.6.1.17 fluid capacitance : Ratio of mass flow to rate of change of *pressure drop.*

4.6.1.18 spurious signals : Unpredicted signals in *control systems.*

4.6.1.19 noise : Random fluctuations of the signal level which may cause undesirable *spurious signals* in a circuit.

4.6.1.20 input impedance : Impedance measured at an *input port.*

4.6.1.21 control volume : Volume of the input chamber, including the pilot line.

4.6.1.22 output power : Power recoverable at the *output port.*

4.6.1.23 output impedance : Impedance measured at an *output port.*

4.6.1.24 active devices : Devices which require a power supply independent of the value of input signals.

4.6.1.25 passive devices : Devices without power supply. Output power is derived solely from the input signals.

4.6.1.26 active output : Output the power of which in all possible states of the device is derived from supply power.

4.6.1.27 inactive [passive] output : Output the power of which in one or more states of the devices is derived solely from the input signals.

4.6.1.28 steady state : See 2.1.5. Condition of a specified variable at a time, when no transients are present. For the purpose of this definition, drift is not considered to be a transient.

4.6.2 properties : Terms applied to express properties and/or characteristics of *fluid logic* and fluid analogue devices of any design, excluding analogue devices with moving parts.

4.6.2.1 amplifier[1] :

NOTE — Energy may be fluid power as well as electric energy.

4.6.2.2 analogue amplifier : *Amplifier* the output of which is continuously variable with the applied control signal.

4.6.2.3 digital amplifier : *Amplifier* the output of which varies in discrete steps related to the control signal.

4.6.2.4 fluidic amplifier : *Amplifier* which is designed for use in fluidic systems.

4.6.2.5 momentum amplifier : Amplifier the operating principle of which is based on the interaction of momentum of the *power* — and control — *jets.*

4.6.2.6 vortex amplifier : *Amplifier* the operating principle of which is based on the *pressure drop* across a *vortex,* modulating the main flow.

4.6.2.7 impact amplifier : *Amplifier* the operating principle of which is based on the control of the impact plane position of opposing *power jets* to control *output power.*

4.6.2.8 turbulence amplifier : *Amplifier* the operating principle of which is based on the transition of a *free* laminar *jet* to turbulence by one or more input signals.

4.6.2.9 wall attachment amplifier : *Amplifier* the operating principle of which is based on the attachment to a wall of the *power jet.* Jet attachment is normally controlled by one or more input signals.

4.6.2.10 interface device : Device which converts information between different types or levels of energy.

4.6.2.11 sensors : Devices that enable a system to detect and transmit changes in external conditions.

4.6.2.12 restrictor : Device which restricts the flow of a fluid thereby creating a *pressure drop.*

4.6.2.13 jet : Emission of a fluid from an orifice.

4.6.2.14 free jet : *Jet* not influenced by its surroundings.

4.6.2.15 main jet; power jet : *Laminar* or *turbulent flow* of fluid emitted from the supply channel or nozzle of a fluidic device.

4.6.2.16 confined jet : *Jet* influenced by its physical surrounding.

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[1] See IEC Publication No. 50(37), 37.30.070.

4.6.2.17 Coanda effect : Phenomenon, named after its discoverer, of the attachment of a free-flowing turbulent *jet* to an adjacent, possibly curved, wall.

4.6.2.18 attached jet : *Jet* which is attached to a wall by *Coanda effect.*

4.6.2.19 control channel : Channel through which the control or input signal enters the device.

4.6.2.20 output channel : Channel through which the output signal leaves the device.

4.6.2.21 receiver; collector : Nozzle located downstream of a free-flowing *jet,* normally used to catch the energy of the flowing medium of the jet.

4.6.2.22 vent : Passage to a reference pressure, normally the ambient pressure.

4.6.2.23 aspect ratio : Ratio of nozzle depth to nozzle width.

4.6.2.24 interaction-region : Chamber in which the *power jet* is affected by one or more control jets.

4.6.2.25 splitter : That part of a fluid *amplifier* which separates alternative outputs.

4.6.2.26 fluid diode : Device with a passage for fluid flow with high, to infinitely high, resistance in one direction and low resistance in the opposite direction.

4.6.2.27 fluid logic device : Types : spool, diaphragm, poppet.

4.6.3 characteristics : Terms and definitions describing performance characteristics as well as the conditions affecting the operating characteristics of *fluid logic* and fluidic devices.

4.6.3.1 load line : Curve expressing *output pressure* as a function of *output flow.* The derivative of this curve is the expression of the *output impedance.*

4.6.3.2 deadhead pressure : *Output pressure* without flow (stagnation pressure).

4.6.3.3 pressure recovery : Ratio of *output pressure to the supply pressure.*

4.6.3.4 flow rate recovery : Ratio of no-load flow at the *output port* to the *supply flow.*

4.6.3.5 power recovery : Maximum ratio of power recovered at the *output port* to the *supply power.*

4.6.3.6 pressure gain : Ratio of *output pressure* change to control pressure change at a given point.

4.6.3.7 flow gain for analogue device : Ratio of the change of *output flow* to the change of *control flow* at a given point.

4.6.3.8 power gain : Ratio of the change of *output power* to the change of control power at a given point.

4.6.3.9 back pressure : See 2.2.4.11.

4.6.3.10 residual pressure : Value of the *output pressure* in the "off" state of the device.

4.6.3.11 FAN-OUT ratio : Number of identical devices which can be controlled by the output of a device.

4.6.3.11.1 series ratio : Number of identical devices mounted in series, which can be controlled by the output of a device.

4.6.3.12 FAN-IN ratio : Number of control inputs available on a device.

4.6.3.13 logic threshold : Minimum number of signals required at the inputs of a multi-input device to change the output condition.

4.6.3.14 acoustic noise : *Spurious signals* generated by external acoustic disturbances.

4.6.3.15 signal-to-noise ratio : Ratio of the value of the signal to that of the noise.

4.7 servo-valve : *Valve* which accepts an analogue control signal and provides a corresponding analogue fluid *power output.*

4.7.1 hydraulic servo-valve : *Valve* which modulates hydraulic output.

4.7.1.1 electro-hydraulic servo-valve : *Hydraulic servo-valve* in which the input command is electrical.

4.7.1.2 mechanical hydraulic servo-valve : *Hydraulic servo-valve* in which the input command is mechanical.

4.7.1.3 flow control hydraulic servo-valve : *Hydraulic servo-valve* the primary function of which is the control of *output flow.*

4.7.1.4 pressure control hydraulic servo-valve : *Hydraulic servo-valve* the primary function of which is the control of *output pressure.*

4.7.1.5 four-way valve : Multi-orifice variable *flow control valve* with supply, return and two control *ports* arranged so that the valve action in one direction throttles supply to control port A (2) and throttles control port B (4) to return. Reversed valve action throttles supply to control port B, and throttles control port A to return.

4.7.1.6 three-way valve : Multi-orifice variable *flow control valve* with supply, return and one control *port* arranged so that valve action in one direction throttles supply to control port and reversed valve action throttles the control port to return.

4.7.1.7 two-way valve : Variable *flow control valve* with a single throttling orifice between the two *ports.*

4.7.2 Construction features

4.7.2.1 force motor : (See 6.5.3.) Used in the input *stages* of *servo-valves.*

4.7.2.2 torque motor : (See 6.5.4.) Used in the input *stages* of *servo-valves.*

4.7.2.3 hydraulic amplifier : Fluid device which acts as an *amplifier.* Hydraulic amplifiers may utilize sliding spools, flapper-nozzles, *jet* pipes, etc.

4.7.2.4 stage : *Hydraulic amplifier* used in a *servo-valve.* Servo-valves may be single stage, two stage, three stage, etc.

4.7.2.5 output stage : Final *stage* of hydraulic amplification used in a *servo-valve.*

4.7.2.6 nozzle flapper : Nozzle and associated impingement plate or disc, which creates a variable gap thereby controlling the *flow rate* passing through the nozzle.

4.7.2.7 port : See 5.2.4.

4.7.3 Electrical characteristics

4.7.3.1 coil impedance : Complex ratio of coil voltage to coil current at specified conditions. It is important to note that the coil impedance may vary with signal frequency, amplitude and other operating conditions, for example, due to back e.m.f. generated by the moving armature.

4.7.3.2 coil resistance : D.C. coil resistance at a specified temperature.

4.7.3.3 dither : Low amplitude, relatively high-frequency periodic electrical signal, sometimes superimposed on the *servo-valve* input to improve system resolution. Dither is expressed by the dither frequency and the peak dither current amplitude in milliamps. Percentage dither is the ratio of dither amplitude to rated signal.

4.7.3.4 input current; input signal : Effective current to the valve which produces a given output.

4.7.3.5 quiescent current : Direct current of opposite polarity in each valve coil when using a differential coil connection producing zero output.

4.7.3.6 rated current; rated signal : Specified *input current* of either polarity to produce *rated flow.* Rated current shall be specified for a particular coil connection (differential, series, or parallel) and does not include null bias current.

4.7.3.7 electrical control power : Power dissipation required for operation of the valve. Control power is a maximum with full *input signal* and is zero with zero-input signal. It is independent of the coil connection (series, parallel or differential) for any conventional two-coil operation. For differential operation (push-pull), the control power is the power consumed in excess of the electrical quiescent power. This power change is a result of the differential current change.

4.7.3.8 electrical quiescent power : Power dissipation required for differential operation when the current through each coil is equal and opposite in polarity.

4.7.3.9 total electrical power : Sum of the instantaneous *control power* and the *quiescent power.*

4.7.3.10 valve polarity : Relationship between the direction of *control flow* and the direction of *input current.*

4.7.4 Steady-state performance characteristics

4.7.4.1 control flow : Flow through the valve control *ports.*

4.7.4.2 rated flow (servo-valve) : Specified *control flow* corresponding to *rated current* at a specified *valve pressure drop.* Rated flow is normally specified as no-load flow.

4.7.4.3 no-load control flow : Flow through the valve control *ports* when there is zero *load pressure drop.*

4.7.4.4 loaded control flow : Flow through the valve control *ports* when there is *load pressure drop.*

4.7.4.5 flow curve : Graphical representation of *control flow* versus *input signal.* This is usually a continuous plot of a complete *cycle* between plus and minus *rated signal* valves at a cycle rate which is unaffected by the valve dynamic characteristics.

4.7.4.6 normal flow curve : Locus of the mid-points of the complete *cycle flow curve.*

4.7.4.7 flow gain (servo-valve) : Mean slope of the *control flow* versus *input signal* curve in any specific operating region. Three operating regions are usually significant with flow control *servo-valves :*

- *the null region;*
- the normal region of flow control;
- the region where flow saturation effects may occur.

Where this term is used without qualification, it is assumed to mean normal flow gain.

4.7.4.8 symmetry : Degree of equality between the *servo-valve* normal *flow gain* of one polarity and that of the reversed polarity. Symmetry is measured as the difference in normal flow gain of each polarity, expressed as percentage of the greater.

4.7.4.9 flow limit : Condition where *control flow* no longer increases with increasing *input signal.*

4.7.4.10 hysteresis : Difference in the valve *input signals* required to produce the same valve output during a single *cycle* of valve input signal when cycled at a rate below that at which dynamic effects are important; it is expressed as a percentage of the *rated signal.* Maximum hysteresis is normally indicated and is the maximum difference in input signal occurring in a cycle shown as a percentage of rated signal.

4.7.4.11 internal leakage (servo-valve) : Total internal valve flow from pressure to return with zero *control flow* (usually measured with control *ports* blocked). Leakage flow will vary with *input pressure* and *input signal.*

4.7.4.12 null [quiescent] leakage : Total *internal leakage* from the valve in the *null* (quiescent) position.

4.7.4.13 lap : In a sliding spool valve, the relative axial position relationship between the fixed and movable flow metering edges with the spool at *null.*

4.7.4.13.1 zero lap : Condition where the fixed and movable flow metering edges coincide with the spool at *null,* giving rise to constant *flow gain* over the null and operational regions.

4.7.4.13.2 overlap : Condition where the fixed and movable flow metering edges do not coincide with the spool at *null* in such a way that a relative displacement between the metering edges shall occur before a *flow path* is created.

4.7.4.13.3 underlap : Condition where the fixed and movable flow metering edges do not coincide with the spool at *null* in such a way that a *flow path* exists across two or more metering edges with the spool at null.

4.7.4.14 travel : Displacement of the valve spool in either direction relative to the geometric *null.*

4.7.4.15 opening : Distance between the fixed and movable flow metering edges, i.e. in considering the valve opening, account shall be taken of the *lap.*

4.7.4.16 flow linearity : Deviation which exists between the *normal flow curve* and an idealized flow curve of slope equal to normal *flow gain. Linearity* is defined as the maximum deviation and expressed as a percentage of *rated signal.*

4.7.4.17 load pressure drop : Differential pressure between the control *ports.* This is denoted as a positive pressure if the higher of the two values is connected to *supply pressure* and the lower to return. A negative value implies that the highest of the load pressures is connected to *return pressure* and the lower to supply. Thus a positive pressure drop denotes an opposing load implying a flow of energy to the actuator while a negative load pressure drop denotes an assisting load implying absorption of energy from the actuator.

4.7.4.18 null : This relates to geometric null which is the zero *control flow* at zero *load pressure drop.*

4.7.4.19 null bias : *Input signal* required to bring the valve to *null,* excluding the effects of valve *hysteresis,* expressed as percent of *rated signal.*

4.7.4.20 null pressure : Equalized pressure existing at both control *ports* at *null.*

4.7.4.21 null region : Region about *null* where the flow gain is effected by parameters such as *lap* and *internal leakage.*

4.7.4.22 null shift : Change in *null bias* expressed as a percentage of *rated signal.* Null shift may occur with changes in *supply pressure,* temperature and other operating conditions.

4.7.4.23 supply pressure; system pressure : Pressure (frequently at nominally constant value) at the supply *port* of the valve.

4.7.4.24 **return pressure; back pressure** : Pressure at the return *port* of the valve.

4.7.4.25 **control pressure** : Pressure existing at either control *port,* which is normally variable between *supply pressure* and *return pressure.*

4.7.4.26 **valve pressure drop** : Sum of the differential pressures across the control orifices of the *output stage.* Valve pressure drop will equal the *supply pressure* minus the *return pressure* minus the *load pressure drop.*

4.7.4.27 **pressure gain** (servo-valve) : Change in *load pressure drop* per unit *input signal* with zero *control flow* (control ports blocked). Pressure gain is specified as the average slope of the curve of load pressure drop versus input signal in the defined region.

4.7.4.28 **resolution** : Increment of *input signal* required to produce a change in valve output at a specified signal level, expressed as a percentage of *rated signal.* Resolution is normally specified as the minimum signal required to cause either an increase or a decrease of *valve* output. If these signals differ, the larger of the two should be quoted.

4.7.4.29 **threshold** : Change of *input signal* required to produce a reversal in valve output at *null,* expressed as a percentage of *rated signal.*

4.7.5 Dynamic performance characteristics

4.7.5.1 **frequency response** : Complex ratio of *control flow* to *input signal* as the current is varied sinusoidally over a range of frequencies. Frequency response is normally measured with constant input signal amplitude and zero *load pressure drop,* expressed as *amplitude ratio* and *phase lag.* Valve frequency response may vary with the input signal amplitude, temperature, *supply pressure* and other operating conditions.

4.7.5.2 **amplitude ratio** : Ratio of the *control flow* amplitude to sinusoidal *input signal* amplitude at a particular frequency, normalized by using a specified low frequency as datum at the same input signal.

4.7.5.3 **phase lag** : This is a measure of the instantaneous time by which the sinusoidal output follows the sinusoidal *input signal* at a specified frequency. This is usually expressed in degrees as the vector angle between input and output.

4.7.5.4 **response time** : See 4.0.7.1.

4.7.5.5 **transfer function** : Differential equation in Carson notation or using the Laplace operator, which uniquely describes the relationship of the controlled flow to the *input signal* at zero load.

5 Energy transfer and conditioning equipment

5.0 General

5.1 Energy sources

5.1.1 **power supply** : Energy source which generates and maintains a flow of fluid under pressure.

5.2 Flowlines, ports and connections

5.2.1 **flowlines** : Pipelines (conductors) for transferring the working fluid.

5.2.1.1 **rigid tubes; semi-rigid tubes** : Pipelines (conductors) of metal or plastic, used for connecting fixed assemblies.

5.2.1.2 **flexible hose** : Flexible pipeline (conductor) usually of wire reinforced rubber or plastic.

5.2.1.3 **working line; feed line** : Main pipelines (conductors) used for the transfer of fluid power.

5.2.1.4 **pump inlet line** : Pipe connected to the *inlet port* of a pump and carrying the supply of working fluid to the *pump.*

5.2.1.5 **return line** : Pipe to return the working fluid to the *reservoir.*

5.2.1.6 **exhaust line** : Pipe to transfer the gas to exhaust.

5.2.1.7 **make-up line; replenishing line** : Pipeline (conductor) to supply working fluid to a circuit to make up losses as required.

5.2.1.8 **pilot control line** : Pipe through which control fluid is supplied for the operation of a pilot control system.

5.2.1.9 **drain line** : Pipe which returns *internal leakage* fluid to the reservoir.

5.2.1.10 **bleed line** : Line through which air is purged from pipes containing liquid.

5.2.2 **connection; fitting** : Leakproof device to connect pipelines (conductors) to one another, or to equipment.

5.2.2.1 **male thread** : *Connection* with external thread.

5.2.2.2 **female thread** : *Connection* with internal thread.

5.2.2.3 threaded union : Straight connector or adaptor with *male* or *female threads.*

5.2.2.4 compression fitting : Type of *fitting* in which the connection is made with the aid of a tubing nut and compression ring which does not require any sealing compound or other method of securing. Fittings may be threaded male or female.

5.2.2.5 flared fitting : Type of *fitting* in which the connection is made with the aid of a tubing nut and a special tool which expands the end of the tubing to provide a seal against the end of the fitting which does not require any sealing compound and may be threaded male or female.

5.2.2.6 tailpiece : *Fitting* inserted into a flexible tube and secured.

5.2.2.7 flange connection : *Connection* consisting of a pair of flanges (sealed) one on each component to be connected.

5.2.2.8 quick release coupling : *Connection* which may be joined or separated without the use of tools. This connection may or may not contain an automatic shut-off valve. (See 5.2.2.12.)

5.2.2.8.1 quick release coupling, bayonet (claw) type : *Quick release coupling* which is connected by a quarter turn of one part with respect to the other.

5.2.2.8.2 quick release coupling, breakaway (pull-break) type : *Quick release coupling* which provides automatic separation of the coupling halves when a predetermined axial force is applied.

5.2.2.9 rotary connection [joint] : *Connection* which permits continuous rotation at the junction between pipelines.

5.2.2.10 swivel connection [joint] : *Connection* which permits angular displacement of pipelines at the point of connection but does not permit continuous rotation.

5.2.2.11 telescopic connection [joint] : Joint consisting of two tubes sliding longitudinally one within the other, to convey the working medium to the equipment.

5.2.2.12 self-sealing coupling : *Connection* which when disconnected, automatically seals one or both lines.

5.2.2.13 spherical joint : Pipe junction allowing relative movement in any direction about a point.

5.2.2.14 cross fitting : Four-port *fitting* in the form of a cross.

5.2.2.15 elbow fitting : *Fitting* shaped to form an angle between mating lines and having a connection port at each end. The angle is always 90°, unless otherwise stated.

5.2.2.16 reducer fitting : *Fitting* having a smaller connection port at one end than the other.

5.2.2.17 tee fitting : Three-port *fitting* in the form of a "T".

5.2.2.18 union fitting : *Fitting* which permits pipes to be joined and separated without requiring the pipes to be rotated.

5.2.2.19 "Y" fitting : Three-port *fitting* in the form of a "Y"

5.2.2.20 take-off point : Auxiliary *connection* on units or pipes for fluid supply or measurement.

5.2.3 flow path; gallery : Passage through which fluid flows within a device.

5.2.4 port : Terminus of a fluid passage in a component to which can be connected pipelines for the transmission of fluid to or from the component.

5.2.4.1 pilot [control] port : *Port* which provides passage for a control fluid.

5.2.4.2 inlet port; input port; supply port : *Port* which provides a passage for the *inlet flow.*

5.2.4.3 output port; outlet port; service port : *Port* which provides a passage for the *outlet flow.*

5.2.4.4 air exhaust port : *Port* which provides passage to the atmosphere.

5.2.4.5 return port : *Port* through which the working fluid passes to the *reservoir.*

5.2.4.6 drain port : *Port* at atmospheric pressure which provides passage to the *reservoir.*

5.2.4.7 air bleed : A device for purging air from a system or component containing hydraulic fluid.

5.2.4.8 air-line drain port : *Port* which enables liquid to be drained from pneumatic circuits.

5.2.4.9 area of port; area of gallery : Minimum area of fluid passage through *port.*

5.2.4.10 manifold port : *Connection* made through a mounting face.

5.2.4.11 Port connection

5.2.4.11.1 threaded port : *Port* arranged to accept screw thread *connections*.

5.2.4.11.2 flanged port : *Port* arranged to accept flanged *connections*.

5.3 reservoir; receiver : Container for storing the working fluid of a power system.

5.3.1 receivers : Vessels for storing air or gas under pressure.

5.3.1.1 main receiver (pneumatic) : Receiver which is installed at the *outlet port* of the compressor to provide for fluctuation in demand.

5.3.1.2 auxiliary receiver (pneumatic) : Receiver which is installed in the system to supply local demands.

5.3.1.3 capacitor : Device capable of storing a signal at a specific point in a fluidic control circuit.

5.3.2 atmospheric reservoir : *Reservoir* for storing liquid at atmospheric pressure.

5.3.3 pressure-sealed reservoir : *Reservoir* sealed for storing fluids at above atmospheric pressure.

5.3.4 sealed reservoir : *Reservoir* sealed for storing fluid isolated from atmospheric conditions.

5.3.5 reservoir fluid capacity : Maximum permitted volume of working fluid which can be stored in a specified *reservoir*.

5.3.6 reservoir expansion capacity : Volume of gas above the maximum liquid capacity level to allow for volume changes, caused by temperature increases etc.

5.3.7 tank (deprecated) : See *reservoir*.

5.3.8 breather capacity : Measure of air *flow rate* through an air breather.

5.4 accumulator : Device for storing hydrostatic energy and subsequently releasing it to do useful work.

5.4.1 hydraulic accumulator : *Accumulator* containing a fluid under pressure and capable of storing hydrostatic energy to do useful work.

5.4.2 spring-loaded accumulator : *Hydraulic accumulator* in which the fluid is subjected to pressure by a spring-loaded piston.

5.4.3 weight-loaded accumulator : *Hydraulic accumulator* in which the fluid is subjected to pressure by the gravitational force acting upon weights being transmitted to the fluid via a piston.

5.4.3.1 gas-loaded accumulator : *Hydraulic accumulator* with or without *separator* in which the fluid is pressurized using the compressibility of an inert gas, nitrogen for example. Fluid and gas may be separated by bladder, diaphragm or piston.

5.4.3.2 gas-loaded transfer type accumulator : *Gas-loaded accumulator* for use with additional gas capacity contained in one or more supplementary gas bottles connected to the gas side of the transfer accumulator by a common pipeline.

5.5 Conditioning of compressed air

5.5.0 General

Terms which apply to the quality, drying, filtration and lubrication of pneumatic supply.

5.5.1 air contamination : *Contaminants* in the air supplied to a system or device (see 10.4).

5.5.1.1 solid contamination : *Contamination* in solid form expressed as percentage of solid particles per unit of mass.

5.5.1.2 liquid contamination : *Contamination* in liquid form expressed in terms of mass per mass of supplied air or gas.

5.5.1.3 vapour contamination : *Contamination* in vapour form expressed in terms of mass per mass at the specified operating temperature.

5.5.1.4 environmental contamination : *Contamination* from the environment expressed in terms of a percentage mass per unit mass of the ambient air.

5.5.2 air filter : Device the primary function of which is the retention of *contaminants* from compressed air and also the removal of free water.

5.5.2.1 filter types : See 5.8.1.

5.5.2.2 filter element : See 5.8.2.

5.5.2.3 clogging : See 5.8.3.

5.5.2.4 filter performance : See 5.8.4.

5.5.3 separator : Device to isolate *contaminants* by physical properties other than size.

5.5.4 water trap : Device fitted at a specific point in the installation in order to collect moisture and possibly other impurities.

5.5.5 oil remover : *Separator* which removes oil from compressed air.

5.5.6 separator drain-valve : Device whereby solid or liquid impurities which have collected in the installation can be removed. May be actuated automatically or manually.

5.5.7 air dryer : Device for reducing the moisture vapour content of the working medium.

5.5.7.1 refrigerant type dryer : Moisture is separated by lowering the air temperature by means of a refrigeration compressor and *heat exchanger.*

5.5.7.2 desiccant type dryer : Moisture is separated by using the adsorptive properties of special compounds.

5.5.7.3 deliquescent type dryer : Moisture is separated by using the absorptive properties of special hygroscopic compounds.

5.5.7.4 regenerative type dryer : Capacity of the dryer to separate moisture can be restored without replacing the drying compound.

5.5.7.4.1 heat regeneration : Application of heat to the saturated drying compound is used to drive off collected moisture.

5.5.7.4.2 heatless regeneration : Air, previously dried at pressure, is expanded to atmospheric pressure and allowed to flow through the saturated compound to drive off collected moisture.

5.5.8 lubricator : Device which introduces a quantity (which may or not be controllable) of lubricant into the working medium.

5.6 heat exchangers : Devices which lower, maintain or raise the temperature of the working medium by heat exchange with another fluid.

5.6.1 cooler : Device which extracts heat from the working medium.

5.6.2 heater : Device which adds heat to the working medium.

5.6.3 temperature controller : Device which maintains the fluid temperature within prescribed limits.

5.7 Silencer

5.7.1 hydraulic silencer : Device to reduce liquid borne noise by attenuation of hydraulic pulsations.

5.7.2 pneumatic silencer : Device to reduce the noise level of intake or exhaust.

5.8 hydraulic filter : Device the primary function of which is the retention of insoluble *contaminants* from a fluid. (See 10.4.1.)

5.8.1 Filter types

5.8.1.1 full-flow filter : Filter which provides no alternative *flow path* around the *filter element.*

5.8.1.2 full-flow filter with bypass : Full-flow filter which provides an alternative *flow path* around the *filter element* when a preset differential pressure is reached.

5.8.1.3 full-flow filter with filtered bypass : *Full-flow filter* in which bypass flow is filtered through a reserve element.

5.8.1.4 duplex filter : Assembly of two filters with valving for selection of full flow through either or both filters.

5.8.1.5 two-stage filter : Filter having two *filter elements* in series.

5.8.1.6 spin-on filter : Filter with an element sealed in its own pressure housing for independent mounting to the hydraulic system.

5.8.1.7 centrifugal type filter : Filter in which separation of *contaminants* occurs when the fluid is accelerated in a circular path.

5.8.1.8 coalescing type filter : Filter in which separation of *contaminants* occurs due to the difference in wetting properties on a particular porous medium leading to liquid particles in suspension uniting into particles of greater volume.

5.8.1.9 strainer : Coarse filter usually of woven wire construction. This may be in the form of a complete filter or just an element.

5.8.1.10 bleed-off filter : Filter located in a line which carries surplus fluid from the main circuit to the reservoir.

5.8.2 filter element : The component which ensures the retention of *contaminant.*

5.8.2.1 cleanable element : *Filter element* which when loaded can be restored by a suitable process to an acceptable percentage of its original flow/pressure differential characteristic.

5.8.2.1.1 self-cleaning element : *Filter element* cleanable either automatically or by manual operation, without removing it from its housing.

5.8.2.2 disposable element : *Filter element* which is intended to be discarded and replaced after use.

5.8.2.3 renewable element : *Filter element* parts of which are replaced to restore the element to its "as new" flow/pressure differential characteristic.

5.8.2.4 full system differential pressure element : *Filter element* which will withstand a pressure differential at least equal to the maximum system operating pressure without structural or filter medium failure.

5.8.2.5 magnetic element : *Filter element* which extracts only ferro-magnetic particles.

5.8.2.6 inside-out flow element : *Filter element* designed for normal flow outward from and perpendicular to its longitudinal axis.

5.8.2.7 outside-in flow element : *Filter element* designed for normal flow towards and perpendicular to its longitudinal axis.

5.8.2.8 two-stage element : *Filter element* assembly composed of two filter elements or media in series.

5.8.3 clogging : Choking, progressive or not, of a porous or fibrous layer or of an apparatus by deposits of solid or liquid particles.

5.8.3.1 clogged element : *Filter element* which has collected a quantity of *contaminant* such that it cannot maintain *rated flow* without excessive differential pressure increase.

5.8.3.2 collapsed element : Inward structural failure of the *filter element* caused by excessive pressure.

5.8.3.3 burst element : Outward structural failure caused by excessive pressure.

5.8.4 Filter performance

5.8.4.1 effective filtration area : Total area of the porous medium exposed to flow in a *filter element.*

5.8.4.2 largest particle passed (sometimes called absolute filtration rating) : Diameter of the largest hard spherical particle that will pass through a filter under specified test conditions.

5.8.4.3 nominal filtration rating : Arbitrary micron value given by the manufacturer to indicate the degree of filtration.

5.8.4.4 filtration ratio : Ratio of the number of particles larger than a specified size per unit volume in the influent to the number of particles larger than the same size per unit volume in the effluent fluid.

5.8.4.5 filter efficiency : Measure of the ability of a filter to remove a specified test *contaminant* from a fluid at a given contaminant concentration under specified test conditions, expressed quantitatively in terms of the probability of a particle o a specified size being retained by the filter. In the case o pneumatic filters it is also expressed quantitatively in terms o the percentage of liquid contaminant retained by the filter.

5.8.4.6 efficiency curve : Curve with the *filter efficiency* as a function of the particle dimensions.

5.8.4.7 dirt capacity; retention capacity : Particle mass which can be retained by the equipment up to the point a which one of the specified operational limits is reached.

5.8.4.8 filter pressure drop : Difference in pressure acros the filter at any given time.

5.8.4.9 maximum permitted filter pressure drop Maximum acceptable pressure drop across the filter arising from the normal direction of flow which can be applied withou structural or medium failure of the *filter element* or significan *contaminant* migration.

5.8.4.10 collapse pressure : Outside-inside differentia pressure which causes structural failure of a *filter element.*

5.8.5 Filter accessories

5.8.5.1 automatic bypass valve : Device which permits unfiltered fluid to bypass the filter element when a preset differential pressure is reached.

5.8.5.2 clogging indicator : Device operated by the differential pressure across the filter element. This device normall indicates that the element has reached its clogged condition

5.8.5.3 magnetic insert : Insert which attracts and retain ferromagnetic particles.

5.8.6 de-aerater : Equipment used to eliminate air or ga contained in the liquid in a hydraulic circuit.

5.9 sealing device : Device which prevents fluid leakage or the entry of *contaminant*.

5.9.1 packing seal : *Sealing device* consisting of one or more mating deformable elements usually subjected to adjustable axial compression to obtain effective radial sealing.

5.9.1.1 mechanical seal : *Sealing device* in which the sealing action is aided by mechanical force and which comprises contact surfaces having relative movement. These surfaces can be in various materials such as metal, carbon, ceramics, etc.

5.9.2 seal : Replaceable element of a *sealing device.*

5.9.2.1 dynamic seal : *Sealing device* used between parts that have relative motion.

5.9.2.2 static seal : *Sealing device* used between parts that have no relative motion.

5.9.2.3 axial seal : *Sealing device* which seals by axial contact pressure.

5.9.2.4 radial seal : *Sealing device* which seals by radial contact pressure.

5.9.2.5 rotary seal : *Sealing device* used between parts that have relative rotary motion.

5.9.2.6 rotary shaft seal : *Sealing device* which seals on the periphery of a rotating shaft.

5.9.2.7 sliding seal : *Sealing device* used between parts that have relative reciprocating motion.

5.9.2.8 piston seal : *Dynamic seal* installed on a piston to maintain a sealing fit with a cylinder bore.

5.9.2.9 rod seal : *Dynamic seal* which seals on the periphery of a piston rod.

5.9.2.10 wiper seal; scraper : *Sealing device* which operates by a wiping action. Used to prevent ingress of contaminant.

5.9.2.11 ring seal : A *seal* in the form of a ring the cross-section of which resembles one of the following :

O ring
U seal
V ring
W
X cruciform seal
□ ▭ square seal

5.9.2.12 cup seal : *Seal* with a radial base integral with an axial cylindrical projection at its outer diameter.

5.9.2.13 flanged seal : *Seal* with a radial base integral with an axial cylindrical projection at its inner diameter.

5.9.2.14 chevron seal : *Radial seal* comprising several mating elements with cross-sections of V form.

5.9.2.15 lip seal : *Seal* which has a flexible sealing projection. Fluid pressure acting on one side of the lip holds the other side in contact with a suitable surface against which to make the seal.

5.9.2.16 anti-extrusion ring; back-up ring : Device in the form of a ring which prevents extrusion of a *seal* into a clearance between the two parts being sealed.

5.9.2.17 labyrinth seal : Type of *rotary seal* in which sealing is achieved by a long leakage path through a fine clearance of varying configuration between relatively rotatable elements.

5.9.3 Seal materials

5.9.3.1 composite seal : *Sealing device* having elements of different materials.

5.9.3.2 bonded seal; bonded washer : Static gasket seal consisting of a flat metal washer bonded to a concentric elastomeric sealing ring.

5.9.3.3 leather seal : Leather for hydraulic duty is usually chrome tanned and impregnated with waxes, rubbers or resins to reduce fluid permeability.

5.9.3.4 cork seal : Normally comprises cork granules bonded together with minor amounts of natural or synthetic rubber or resins. Fluid resistance will depend mainly on the bonding medium.

5.9.3.5 elastomer seal : Material having rubber-like properties, i.e. having the capacity for large deformation and rapid and substantially complete recovery on release from the deforming force.

5.9.3.5.1 nitrile rubber seal : Material composed of copolymers of butadiene and acrylonitrile (resistance to petroleum base fluids varies according to the acrylonitrile content of the polymer).

5.9.3.5.2 butyl rubber seal : Material composed of copolymer of isobutylene and isoprene exhibiting good chemical and ozone resistance and low permeability to gas. (Resistant to a number of phosphate ester fluids but not to petroleum-based fluids.)

5.9.3.5.3 silicone rubber seal : Polysiloxanes having inorganic molecular chains with attached organic groupings. They are outstanding amongst rubbers in their retention of rubber-like properties over a very wide temperature range.

5.9.3.5.4 polychloroprene rubber (neoprene) **seal** : Material composed of polychloroprene (has fair-to-good resistance to petroleum-based fluids and good resistance to ozone and weathering).

5.9.3.5.5 fluorinated rubber (VITON) **seal** : Fluorinated rubber having outstanding chemical and fluid resistance. Resistance to high temperature is excellent. Low temperature characteristics are poor.

5.9.3.5.6 polytetrafluoroethylene (PTFE) **seal** : Thermoplastic polymer which is virtually immune to chemical attack and which may be used over a very wide temperature range. Coefficient of friction is very low but flexibility is limited and recovery characteristic only moderate.

5.9.3.5.7 polyurethane seal : Material comprising mainly socyanate having good resistance to petroleum-base fluids and to abrasion, liable to degradation in the presence of water at moderate temperatures.

5.9.3.5.8 ethylene propylene rubber seal : Copolymer of ethylene and propylene. Resistant to phosphate ester fluid but not to mineral oils.

5.9.3.5.9 polyacrylic rubber seal : Copolymer of acrylate of ethyl. Good resistance to mineral oils. Resistance to heat is better than that of nitrile rubbers.

5.9.3.5.10 polyamide (NYLON) **seal** : Polyamide thermoplastic materials characterized by their high strength and resistance to abrasion.

6 Control mechanisms

6.0 automatic control : Control method which operates without human intervention.

6.1 Mechanical components

6.1.1 rotating shaft : Rotary mechanical control component.

6.1.2 detent : Device which retains the valving element in position by means of artificially created resistance. Movement to a different position is achieved either by release of the detent, or by the application of sufficient force to overcome it.

6.1.3 latch : Moving parts are retained in a fixed position by means of a locking device which cannot be released until certain specified conditions are fulfilled.

6.1.4 over-centre device : Moving parts cannot stop in an intermediate position (dead centre position).

6.1.5 linkage : Means of mechanical connection.

6.2 manual control : Control device which is manually operated.

6.2.1 button : Control device finger operated by pushing.

6.2.2 lever : Pivoted arm which is hand-operated by pushing or pulling.

6.2.3 pedal : Control device foot-operated in one direction only.

6.2.4 treadle : Control device foot-operated in two directions.

6.3 mechanical control : Control method which is operated by mechanical elements, such as, shaft, cam, lever, etc.

6.3.1 plunger : Rod acting in the direct line of the application of force.

6.3.2 spring return : Moving parts of the unit are returned to the initial position by spring force after the actuating forces have been removed.

6.3.3 roller : Device attached to the operating mechanism to permit operation by means of a cam or slide acting at right angles to the mechanism.

6.3.3.1 roller lever : *Lever* with *roller* attached transmitting movement.

6.3.3.2 roller plunger : *Plunger* with *roller* attached permitting the transmission of movement at right angles to the mechanism.

6.3.3.3 roller rocker : *Lever* pivoted between *rollers* attached at each end, transmitting movement in both directions of the operating mechanism.

6.3.3.4 one-way trip : Mechanism which will allow movement in one direction only of the actuating force.

6.4 pressure control : Control method operated by a change of fluid pressure in a *pilot control line.*

6.4.1 direct pressure control : Control method in which the position of the moving parts is controlled directly by alteration of the control pressure.

6.4.2 indirect pressure control : Control method in which the position of the moving parts is controlled by a change of the control pressure to a pilot device.

6.4.3 cylinder control : Form of *pressure control* in which a fluid cylinder is the operating member.

6.4.4 pneumatic control : *Pressure control* using air in a *pilot control line.*

6.4.5 hydraulic control : *Pressure control* using liquid in a *pilot control line.*

6.5 electrical control : Control method operated by a change of electrical state.

6.5.1 single-acting solenoid : Electro-magnetic mechanism which can take up two positions, being operated to one extreme position by energizing the coil.

6.5.2 two-way solenoid : Electro-magnetic mechanism which can take up two or three positions and is operated to either extreme position by energizing the appropriate coil.

6.5.3 force motor : Type of electro-mechanical transducer having linear motion.

6.5.4 torque motor : Type of electro-mechanical transducer having rotary motion.

6.5.5 stepping motor : Electric motor designed to provide displacement or speed variation in successive steps.

6.5.6 tracer control : Control operated by a system which follows the contours of master pattern.

6.6 combined control : Control system comprising two or more of the elements described in 6.2, 6.3, 6.4 and 6.5.

6.7 servo control : Control method in which a signal representing the required state of the controlled element is compared with a signal representing the actual state the controlling element takes up a position determined by the difference between these signals.

6.7.1 feedback : Means whereby the state of the controlled element is signalled.

6.7.1.1 mechanical feedback : *Feedback* using a mechanical transmission.

6.7.1.2 hydraulic feedback : *Feedback* using a hydraulic circuit.

6.7.1.3 electrical feedback : *Feedback* using an electrical signal.

6.7.1.4 pneumatic feedback : *Feedback* using a pneumatic circuit.

6.8 auxiliary control : Device, usually manual, fitted to a valve to provide an alternative method of control.

6.8.1 override control : Alternative method of control fitted to a valve, which takes precedence over the normal method of control.

6.8.2 emergency control : Device, usually manual, fitted to a valve or circuit providing an alternative method of control in the case of failure of the normal method of control.

7 Additional apparatus

7.1 Measuring instruments

7.1.1 pressure measuring instrument : Device which indicates the level, variations or differences of pressure.

7.1.1.1 pressure gauge : Device which indicates the pressure of a fluid usually by means of a mechanical pointer moving over a scale. Pressure gauges usually indicate pressures relative to ambient atmosphere level and may indicate above or below ambient for example vacuum gauges.

7.1.1.2 manometer : Device which indicates fluid pressure by liquid levels usually employing a U-tube filled with mercury or water. The level of the liquid above or below a reference point indicates the fluid pressure relative to ambient pressure. Unless otherwise specified, it indicates the fluid pressure relative to ambient atmospheric pressure.

7.1.1.3 electrical pressure transducer : Device which converts fluid pressure to an electrical signal.

7.1.1.4 pressure recorder : Instrument which provides a permanent record of pressure usually on paper, film or tape.

7.1.1.5 absolute pressure instrument : Instrument which shows the absolute pressure of the fluid in relation to a theoretically perfect vacuum.

7.1.1.6 differential pressure instrument : Instrument which measures the difference between two pressures.

7.1.2 flow measuring instrument : Device which measures the *flow rate* of a fluid.

7.1.2.1 flowmeter : Device which directly indicates the *flow rate* of a fluid.

7.1.2.2 integrating flowmeter : Instrument which indicates the total quantity of the fluid that has flowed past the measuring point.

7.1.2.3 electrical flow transducer : Device which converts fluid flow to an electrical signal.

7.1.2.4 flow recorder : Instrument which provides a permanent record of fluid flow usually on paper, film or tape.

7.1.3 liquid level measuring instrument : Device which indicates the level of liquid.

7.1.3.1 sight glass : Transparent device connected to a *reservoir* to show the position (height) of the liquid surface.

7.1.3.2 dipstick : Removable graduated rod for indicating the level of the contents of a *reservoir.*

7.1.3.3 reservoir level gauge : Device which converts changes of liquid level into mechanical motion and by means of a pointer over a scale indicates the level of the liquid in a *reservoir.*

7.1.3.4 reservoir contents gauge : Device which senses either the liquid height, mass or pressure in a *reservoir* and displays it, usually by mechanical pointer on a scale graduated in tank contents. It can also consist of a *sight glass* with a scale calibrated in cubic content instead of depth of fluid.

7.2 indicators : Devices which show the presence or absence of a phenomenon such as pressure or *flow,* but which do not measure it.

7.2.1 pressure indicator : Device which changes fluid pressure into mechanical motion and usually by means of a plunger indicates the presence or absence of pressure. These devices usually do not indicate the exact pressure but show whether the fluid pressure is above or below a predetermined level.

7.2.2 flow indicator : Device employing a ball, vane or other means inside a transparent cover. Motion of the ball or vane indicates that fluid is flowing through the pipeline.

7.3 Switches

7.3.1 pressure switch : Device incorporating an electrical switch in which actuation of the contacts is effected at a predetermined fluid pressure.

7.3.2 flow switch : Device incorporating an electrical switch in which actuation of the contacts is effected at a predetermined instantaneous *flow rate.*

7.3.3 liquid level switch : Device incorporating an electrical switch in which actuation of the contacts is effected at a predetermined level of the liquid.

7.3.4 differential pressure switch : Device incorporating an electrical switch or switches in which actuation of the contacts is effected at predetermined values of differential pressure.

7.4 Other apparatus

7.4.1 pneumatic time delay unit; pneumatic timer : Device so arranged that, if a continuous pneumatic signal is applied to or removed from the *input port,* a signal will be produced at the *output port* after a predetermined time has elapsed. The time delay may be fixed or variable.

7.4.1.1 pulse generator : Device so arranged that, if a continuous pneumatic signal is applied to the *input port,* repetitive pulses are produced at the *output port.*

7.4.1.2 impulse generator : Device so arranged that, if a continuous pneumatic signal is applied to the *input port,* a single pulse is produced at the *output port.*

7.4.2 pneumatic programmer : Calibrated device so arranged that, if a continuous pneumatic signal is applied to the *input port,* one or more output signals will be produced. The duration of and interval between the outputs can be predetermined.

7.4.3 gauge pulsation damper : Device employing a fixed or variable restrictor inserted in the pipeline to a pressure gauge, to prevent damage to the gauge mechanism caused by rapid fluctuations of fluid pressure.

7.4.4 gauge protector : Device inserted in the pipeline to a pressure gauge and arranged to isolate the pressure gauge from the fluid pressure if this exceeds a predetermined limit. The device can usually be adjusted to suit the range of the pressure gauge.

7.4.5 controller : Device which senses a change of fluid state and automatically makes adjustments to maintain the state of the fluid between predetermined limits, for example pressures, temperatures, etc.

8 Assemblies

8.0 General

Combinations of equipment to perform the required functions.

8.0.1 fluid power system : Arrangement of interconnected components which transmits and controls power by the use of pressurized fluid within an enclosed circuit.

8.1 Driven assemblies

8.1.1 power unit; powerpack : Assembly of motor-driven pump, with or without a *reservoir,* and the necessary accessories (sometimes including controls, *pressure relief valve* etc.).

8.1.2 compressor installation : Assembly of motor, compressor, *receiver,* regulator, etc.

8.1.2.1 pneumatic unloading device : Device which allows the compressor to run with no load when a predetermined pressure is reached.

8.1.2.2 start-stop pressure control : System using a *pressure switch* which automatically starts or stops the compressor according to a preset maximum and minimum pressure setting.

8.1.2.3 pneumatic variable speed control : The speed of the compressor varies automatically according to the air consumption.

8.2 Motor assemblies

8.2.1 hydraulic motor assembly : Combination of hydraulic motor, *pressure relief valve* and *control valve.*

8.2.2 pneumatic motor assembly : Combination of pneumatic motor, *pressure relief valve* and *control valve.*

8.2.3 linear motor : *Cylinder* with built-in control unit by which the piston rod is automatically reciprocated.

8.3 Control and regulation assemblies

8.3.1 pneumatic amplifier assembly : Device which converts low-level pneumatic control signals into pneumatic output signals of a higher energy level.

8.3.2 cyclic pneumatic programmer : Apparatus comprising a number of valves controlled by a programming device with a repetitive action. The programme may be either fixed or variable.

8.3.3 flow amplifier : Device which amplifies flow by use of a small valve which acts as a pilot for a larger one.

8.4 air conditioner unit : Assembly comprising a filter, reducing valve with a *pressure gauge* and a *lubricator,* intended to deliver fluid in suitable condition.

8.5 fluid power circuit : Arrangement of interconnected fluid power components.

8.5.1 pilot circuit : Circuit used to control a main circuit or component.

8.5.2 pressure control circuit : Circuit the main purpose of which is to adjust or regulate fluid pressure in the system or any branch of the system.

8.5.3 safety circuit : Circuit which prevents accidental or dangerous operation, protects against overloads or otherwise assures safe operation.

8.5.4 regenerative circuit : Circuit in which discharge fluid from a component, usually a cylinder, is *directed* to the input of the component or system, the object being to increase actuator speed at the penalty of reduced actuator force.

8.5.5 sequence circuit : Circuit which establishes the order in which two or more *phases* of a *cycle* occur.

8.5.6 servo circuit : Circuit used for *servo control.*

8.5.7 speed control circuit; flow control circuit : Circuit the purpose of which is to control speed of operation usually by regulating flow.

8.5.7.1 meter-in circuit : *Speed control circuit* in which the control is achieved by regulating the supply flow to the actuator.

8.5.7.2 meter-out circuit : *Speed control circuit* in which the control is achieved by regulating the exhaust flow from the actuator.

8.5.8 synchronizing circuit : Circuit in which multiple operations are controlled to occur at the same time.

8.5.9 unloading circuit : Circuit in which pump output is returned to *reservoir* at minimum pressure whenever delivery to the system is not required.

8.5.10 open circuit : Circuit in which return fluid is directed to the *reservoir* before re-circulation.

8.5.11 closed circuit : Circuit in which return fluid is directed to the pump inlet.

9 Complete installations — Assemblies

9.0 General

9.1 installation : The arrangement of a *fluid power system* in relation to its associated machinery and site.

9.1.1 Types

9.1.1.1 fixed installation : *Installation* in a permanent immovable location.

9.1.1.2 portable installation : *Installation* in equipment which may be moved between working locations but which does not operate while being moved.

9.1.1.3 mobile installation : *Installation* on a machine which moves while operating.

9.1.1.4 integral installation : *Installation* in which major components of the *fluid power system* form part of the structure of the machine.

9.1.2 prime mover : Device which serves as the source of mechanical power for the *fluid power system;* i.e. that which drives the pump or compressor (electric motor, internal combustion engine).

9.1.3 Auxiliary components and equipment

9.1.3.1 pipe installation; pipe-work : (See 5.2.) Arrangement of the fluid pipes in the *fluid power system* and its associated machine.

9.1.3.1.1 pipe clamp : Device to hold and support *pipework.*

9.1.3.2 anti-vibration mounting : Device for insulating machine vibrations from the structure upon which it is mounted.

9.1.3.3 drive shaft coupling : Device which connects two rotating shafts axially and transmits torque between them. (Usually permits a small degree of misalignment and sometimes provides torsional flexibility.)

9.1.3.4 guard : Safety device, usually of sheet metal or wire mesh, which protects personnel from injury by moving machine parts, for example, pump drive shafts, shafts, *cylinder* rods.

9.1.4 control systems : Means whereby the *fluid power system* is controlled, linking that system to the operator and to control signal sources, if any. (See clause 6.)

9.1.4.1 operating station : Location of operators' controls.

9.1.4.2 control console : Frame containing control *buttons,* switches, *levers,* etc. and necessary instrumentation, usually in the form of a desk with a vertical rear panel for gauges.

9.1.4.3 control panel : Vertical panel to carry gauges, switches and other control devices.

9.1.4.4 mechanical control system

9.1.4.5 pneumatic control system

9.1.4.6 hydraulic control system

9.1.4.7 electric control system

9.1.4.8 electronic control system

9.1.4.9 mixed control system

9.1.4.10 remote control system : *Control system* in which the operating station is distant from the *fluid power system.*

9.1.5 cooling system : Means whereby unwanted heat is removed from the working fluid or from components.

9.1.5.1 water cooling : *Cooling system* in which water is the transfer medium by which heat is removed. Ultimately the water is air cooled (see 9.1.5.2).

NOTE — Other coolant liquids can be used but these are unusual.

9.1.5.2 air cooling : *Cooling system* in which air is the transfer medium.

9.1.5.3 heat exchanger (fluid cooler) : See 5.6.

9.1.5.3.1 radiator : Device, usually of honeycomb or multitubular construction which transfers heat from a liquid to air, thereby acting as a liquid/air *heat exchanger.*

9.1.5.3.2 cooling fan : Device which mechanically creates a flow of air over a hot surface, usually used with a *radiator* in order to increase the rate of heat exchange.

9.1.5.4 refrigeration cooling : *Cooling system* which uses refrigeration techniques, i.e. uses a liquid which, when caused to assume the vapour state, absorbs heat at a high rate during the change of state.

9.2 Commissioning and maintenance

9.2.1 commissioning : Act of operating, testing and adjusting a system or unit for the first time to ensure that it functions according to the specified performance. Functional tests will include the extremes of the required specification.

9.2.1.1 system cleaning : Removal of *contaminant* from all fluid passages and internal spaces to which the working fluid has access.

9.2.1.2 system flushing : Operating the system containing a special cleaning fluid (flushing oil) at low pressure to clean the inner passages and cavities in the circuit. The flushing oil is replaced by the correct working fluid before the system is put into normal service.

9.2.1.3 system filling : Act of filling the system with the specified amount of fluid.

9.2.1.4 system bleeding : Removing pockets of air trapped in the circuit. Usually carried out at low pressure by means of small *valves* or *connections* at high points. Removing water in the air circuit with *separator drain-valve.*

9.2.1.5 system draining : Drawing off of fluid from a system, usually by means of a suitably positioned *shut-off valve.*

9.2.1.6 initial starting : Specified sequence of operations for starting a unit or system for the first time or re-starting after *maintenance,* repair or long period of shut-down. Includes functional verification.

9.2.1.7 system [unit] function test : Act of testing the unit or system to ensure that output functions make the correct response to input signals.

9.2.2 maintenance; service : Process of inspecting or checking a unit or system to ensure it is functioning correctly, or to determine why it is not operating correctly. Repairing or renewing defective or damaged components, adjusting settings and controls to maintain the required or specified performance.

9.2.2.1 preventive maintenance : Act of checking over a unit or system at prescribed intervals, making adjustments to settings which have changed, repairing or replacing components which are damaged or show signs of failure or which, from experience are known to have reached their predetermined useful life and the application of lubricants, where required. By this means, a machine, system or *installation* is kept in good working order and failures are reduced to a minimum.

9.2.2.2 spare parts : Component parts, sub-assemblies or complete assemblies, identical to or interchangeable with those in a system, held in store to carry out a repair or maintenance operation with the minimum of delay.

9.2.3 Documentation

9.2.3.1 performance specification : Document detailing the functional requirements of a piece of equipment, complete system or *installation* and, when applicable, the environmental conditions and any peculiar or specific conditions to which it will be subjected.

Sufficient detail shall be given to enable the manufacturer to select the correct materials and components to meet the requirement and, conversely, to enable the customer to determine whether the products offered are to his satisfaction.

9.2.3.2 system specification : Document detailing the materials, functional performance and standard of a piece of equipment or complete system or *installation* to meet the *performance specification.* The document will contain sufficient details to enable the manufacturer to select and determine the material and components necessary to fulfil the requirements of the customer and, conversely, to allow the customer to determine whether the products offered are to his satisfaction.

9.2.3.3 installation manual : Document detailing all materials and *services* required, mounting facilities, relative disposition of units and means of connecting equipment in preparation to *commissioning* and starting up of a new *installation* or piece of equipment.

9.2.3.4 commissioning manual : Document detailing the quantity and type of fluid, electrical or other services and procedures to be followed before starting equipment for the first time. It will also detail the sequence of operations and observations to be made to ensure correct function of the equipment when first operated.

9.2.3.5 operating manual : Document detailing the sequence of operations, adjustments and observations to be made ensuring correct use and operation of equipment, following satisfactory installation and *commissioning.*

9.2.3.6 maintenance manual : Document detailing the disciplines and procedures to be followed to maintain an item of equipment, complete machine or system in good working order. It will detail periodic checks and replacement of parts, type of lubricant and protective processes and the period of time between each check.

It will include instructions on how to locate faults, carry out repairs and the replacement of components. It may also include a detailed list of the components which go together to make the complete unit, and their reference numbers and quantity required to assist purchase of replacements as required.

9.2.3.7 parts list : Document listing and identifying components and assemblies which make up the unit, module or system.

9.2.3.7.1 spare parts list : Document detailing the quantity and type of components, sub-assemblies and units recommended by the equipment manufacturer to be held in store for *preventive maintenance* and general repair to keep the equipment in good working condition.

10 Hydraulic fluids

10.0 General

10.0.1 hydraulic fluids : Fluids suitable for use in hydraulic systems. They are produced from either petroleum products or aqueous or organic materials.

10.0.2 newtonian fluid : Fluid having a *viscosity* that is always independent of the rate of shear.

10.1 Classification of fluids

10.1.1 petroleum fluid; mineral oil : Fluid composed of petroleum hydrocarbons which may contain other constituents.

10.1.2 fire resistant (FR) fluid : Fluid difficult to ignite which shows little tendency to propagate flame.

10.2 Fluid types

10.2.1 aqueous fluid : Fluid which contains water as a major constituent besides the organic material. The fire resistance properties are derived from the water content.

10.2.2 oil-in-water emulsion : Dispersion of oil in a continuous phase of water.

10.2.3 water-in-oil emulsion : Stabilized dispersion of water in a continuous phase of oil.

10.2.4 polyglycol solution : Fluid in which the major constituents are water and one or more glycols or polyglycols.

10.2.5 synthetic fluid : Fluid produced by synthesis rather than by extraction or refinement. It may contain *additives.*

10.2.6 chlorinated hydrocarbon fluid : Aromatic or paraffinic hydrocarbon fluid in which certain hydrogen atoms are replaced by chlorine. The fire resistance is derived from the chlorine present.

10.2.7 di-basic acid ester fluid : Fluid manufactured by the reaction of a di-basic acid with a monohydric alcohol.

10.2.8 halogenated fluid : Fluid composed of halogenated (chlorine, fluorine, bromine, iodine) organic compounds. It may contain other constituents and is found in industry usually as a chlorinated hydrocarbon fluid.

10.2.9 phosphate ester fluid : Fluid composed of phosphate ester which may contain other constituents. Its fire resistant property is derived from the molecular structure of the fluid.

10.2.10 phosphate ester base fluid : Fluid composed of phosphate ester as one of its main constituents.

10.2.11 polyglycol ester fluid : Fluid obtained by reacting an acid with di-hydric alcohol, usually polyethylene or polypropylene glycol. The fluid is not fire resistant and is thus usually to be found as an *additive.*

10.2.12 silicone fluid : Fluid composed of silicones. It may contain other constituents.

10.2.13 silicate ester fluid : Fluid composed of organic silicates. It may contain other constituents.

10.2.14 additive : Chemical added to a fluid to impart new properties or to enhance those which already exist.

10.2.15 viscosity index improver : Chemical compound added to a fluid to modify its temperature/viscosity relationship.

10.2.16 inhibitor : Any substance which, present in very small proportions, slows, prevents or modifies chemical reactions such as corrosion or oxidation.

10.2.17 anti-freeze : Any substance introduced into the working fluid which depresses the freezing point, applicable only to fluids which contain water.

10.3 Characteristics of fluids

10.3.1 viscosity : Resistance of a fluid to flow resulting from internal friction.

10.3.1.1 kinematic viscosity : Ratio of the absolute viscosity to the mass density of a fluid.

10.3.1.2 absolute viscosity; dynamic viscosity : Ratio of the shearing stress to the shear rate of a fluid.

10.3.1.3 viscosity index : Empirical measure of the viscosity/temperature characteristics of a fluid. When the variation is small, the index is high.

10.3.1.4 compressibility : See *bulk modulus.*

10.3.2 water content : Quantity of water contained in a fluid *(mineral oil).*

10.3.3 density : Quotient of the mass of a fluid by its volume at a specified temperature (15 °C).

10.3.4 air release : Ability of a fluid to release air bubbles dispersed therein.

10.3.5 seal compatibility : Ability of an elastomer to resist the action of a fluid on dimensions and mechanical properties.

10.3.6 neutralization value : Measure of the acidity and basicity of a fluid. It is expressed as an equivalent of an acid or alkali required to neutralize the fluid.

10.3.7 copper corrosion : Indicated by the change of appearance of an electrolytic copper plate immersed in the fluid under stated conditions.

10.3.8 foam; aeration : More or less stable extended air-liquid interface arising when bubbles persist at the surface of a fluid.

10.3.9 pour point : Lowest temperature at which a fluid will flow under specified conditions.

10.3.10 flash point : Temperature at which the fluid shall be heated to give off sufficient vapour to cause it to ignite in the presence of air when a small flame is applied under controlled conditions.

10.3.11 fire point : Temperature to which a fluid shall be heated to ignite and burn for 5 s in the presence of air when a small flame is applied under controlled conditions.

10.3.12 auto ignition temperature (AIT) : Temperature at which a fluid will ignite when dripped by a pipette into a heated flask; AIT is calculated at 5 °C below the temperature at which ignition takes place.

10.3.13 bulk modulus : Relationship of applied stress and volumetric strain produced when stress is applied uniformly to all sides of a body. It is the reciprocal of *compressibility.* (See 10.3.1.4.)

10.3.14 water demulsibility : Capacity of an emulsion of fluid and water to separate into two phases.

10.3.15 saponification value : Measure of the free and combined acids in oils reacting with potassium hydroxide. The result is expressed as milligrammes of potassium hydroxide per gramme of fluid.

10.3.16 ash content : Percentage in weight of the residue after calcination of the fluid under defined conditions.

10.3.17 rust protection : Capacity of a fluid to prevent the formation of rust under specified conditions.

10.3.18 miscibility : Capacity of fluids to be mixed together without detrimental results.

10.3.19 vapour pressure: Pressure exerted at any temperature by a vapour fluid existing in equilibrium with its liquid phase.

10.3.20 evaporation deposits : Percentage of residue obtained after evaporation of the product in free air.

10.3.21 surface tension : Contractile surface force of a liquid by which drops tend to assume a spherical form and to present the least possible surface.

10.3.22 anti-corrosive qualities : Evaluation, under standard conditions, of the corrosive action of a fluid on one or several metals. Particularly important in the case of water-containing fluids.

10.3.23 stability : Resistance of a fluid to permanent change in its properties under normal storage and service conditions.

10.3.23.1 shear stability : Ability of a fluid to maintain its properties under operating conditions with respect to its *viscosity.*

10.3.23.2 emulsion stability : *Stability,* under defined storage conditions, of an emulsion.

10.3.23.3 oxidation stability : Ability of a fluid to resist permanent change in its properties due to reaction with the atmosphere.

10.3.24 anti-wear properties; lubricity : Ability of a fluid to prevent metal-to-metal contact by maintaining a film of material between moving surfaces under known operating conditions.

10.3.24.1 anti-wear vane pump test : Test to determine the anti-wear properties of *hydraulic fluids* by means of a vane type hydraulic pump. It is for fluids intended for use in applications with high speed sliding steel-on-steel contacts such as are encountered in a *vane pump.*

10.3.25 flow temperature : See *pour point*.

10.3.26 toxicity test : Test to determine the insalubrious biological or environmental effect of fluids when consumed, in contact with the person, ignited or heated.

10.3.27 fire resistance tests (FR fluids) : Tests applied to fire resistant (FR) fluids to determine their resistance to ignition (flammability), persistence of burning and heat output.

10.3.27.1 high pressure spray test : Test to determine the flammability of a pressurized jet or atomized spray by a controlled ignition source.

10.3.27.2 wick test : Test to determine the persistence of burning of a *hydraulic fluid* by placing a length of woven asbestos tape, which has been soaked in the sample, in a *reservoir* with one edge exposed, forming a wick. A flame is temporarily applied to the exposed edge of the wick and the persistence of the flame on the wick measured.

10.3.27.3 manifold ignition test : Method used for determining the relative flammability of a liquid in contact with a hot surface.

10.3.27.4 effects of evaporation : This method consists of checking the flammability of the liquid by passing a pipe cleaner, which has been soaked in the sample, repeatedly through a flame and noting the number of passes required for ignition.

10.3.27.5 ignition on CFR motor at a variable compression rate : Fire resistance is determined by the minimum volumetric compression ratio which produces combustion of the fluid in a variable compression ratio diesel engine.

10.4 contamination : Introduction or presence of *contaminants* or undesirable modifications to the composition of the liquid or gaseous medium.

10.4.1 contaminant : Undesirable solid, liquid or gaseous material present in the liquid or gaseous medium.

10.4.1.1 initial contamination : *Contaminants* existing when a component fluid or system is put into service.

10.4.1.2 environmental contaminant : *Contamination* introduced from the immediate surroundings of a system into its fluid or components.

10.4.1.3 generated contamination : *Contaminant* produced during the use of a system or a component.

10.4.1.4 particles : Small portion of solid (or liquid) matter present in the fluid, for example dust, fibres, metal, etc.

10.4.1.5 dissolved air : Air dispersed at a molecular level in a *hydraulic fluid* and apparently forming only a single phase.

10.4.1.6 entrained air : Air (or gas) forming an emulsion with the liquid in which the bubbles tend to separate from the liquid phase.

10.4.1.7 free water : Water entrained in a *fluid power system* forming two distinct phases with the fluid and having a tendency to separate as a result of their *densities*.

10.4.1.8 migration : Transitional *particles* in a system.

10.4.1.9 silting : Accumulation of fine *particles* at a specific location in a fluid system.

10.4.2 Contamination characteristics

10.4.2.1 mass index of contamination : Mass (weight) of *particles* contained in a unit volume of fluid.

10.4.2.2 visual counting of contamination : Any method allowing the evaluation of the *contamination* in a fluid by an optical counting procedure.

10.4.2.3 automatic counting of contamination : Any method allowing the evaluation of the *contamination* in a fluid by an automatic counting procedure.

10.4.2.4 raw count : Actual number counted in each *particle* size range in a given sample (see 10.4.2.8).

10.4.2.5 total statistical count : *Raw count* multiplied by a counting calibration factor.

10.4.2.6 particle size distribution : Presentation, in the form of a table of numbers or in graphical form, of the experimental results obtained using a method or an apparatus capable of measuring the equivalent diameter of *particles* in a sample or capable of giving the proportion of particles for which the equivalent diameter lies between two limits.

10.4.2.7 rate [level] of contamination : Every result of measurement characterizing the *contamination* of a fluid in the form of one number. The criterion adopted in this case could be : either a numeration of *particles*, or the measurement of the major physical characteristic (mass, surface after deposit on the filter). Thus it could be called "rate of pollution" of a qualitative kind or "numerical, gravimetric, photometric...".

10.4.2.8 contamination classes : Having arbitrarily defined the grades, a certain number of classes can be established and a numerical grid fixed for each class and for each grade a numerical limit of *particles* not to be surpassed by a unit of volume. Having established the numerical distribution of *contamination*, it is said that a sample of fluid is contained in a class if for any grade, the number of particles does not surpass the maximum number given for the limit.

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